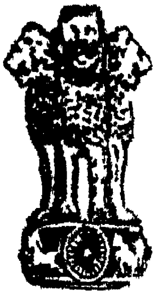

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VOLUME 82. PART I

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OF THE
GEOLOGICAL SURVEY OF INDIA

DIRECTOR

A. HEADQUARTERS

DEPUTY DIRECTOR
(MINERAL DEVELOPMENT)

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- PALÆONTOLOGICAL LABORATORY
- PALÆOBOTANICAL LABORATORY
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B. FIELD CIRCLES

(THE FIVE CIRCLES SHOWN BELOW ARE RESPONSIBLE FOR ALL FIELD INVESTIGATIONS OTHER THAN THE WORK ALLOTTED TO THE SPECIALIST SECTIONS)

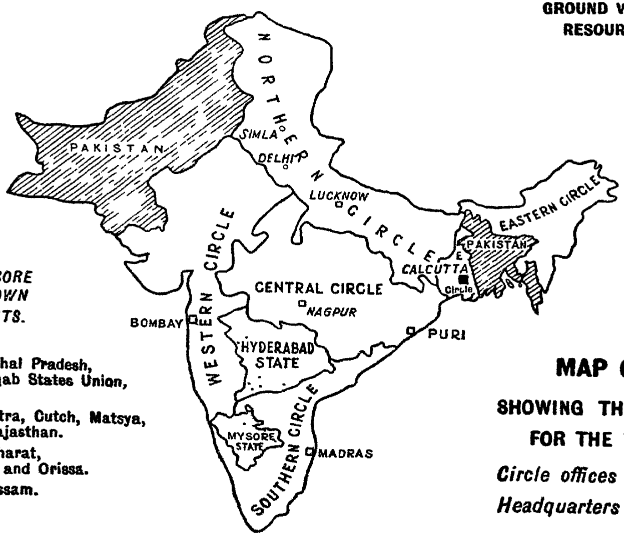
C. SPECIALIST SECTIONS

ENGINEERING GEOLOGY & GROUND WATER DIVISION

- ENGINEERING GEOLOGY
- GROUND WATER RESOURCES

MINERAL DEVELOPMENT DIVISION

- GEOPHYSICS
- DRILLING
- EXPLORATORY MINING
- MINERAL PROSPECTING
- RARE MINI



MAP OF INDIA

SHOWING THE FIELD CIRCLES
FOR THE YEAR 1947-48

Circle offices shown thus ...... □
Headquarters .... ■

NOTE: *HYDERABAD & MYSORE STATES HAVE THEIR OWN GEOLOGICAL DEPARTMENTS.*

Northern Circle	E. Punjab, Himachal Pradesh, Patiala & E. Punjab States Union, U. P. and Bihar.
Western Circle:	Bombay, Saurashtra, Cutch, Matsya, Rajputana and Rajasthan.
Central Circle:	C. P., Madhya Bharat, Vindhya Pradesh and Orissa.
Eastern Circle:	W. Bengal and Assam.
Southern Circle:	Madras.

I. INTRODUCTION

In the Introduction to the General Report for 1947[1], the functions of a Geological Department were briefly outlined, and the manner in which the expanding Department was being organised was explained. There is no need to repeat this.

During the year 1948 the expansion of the Department made steady progress, and 115 posts against the target of 141 gazetted officers had been filled by the end of the year. In addition a number of non-gazetted technical posts, designated Geological Assistants and Geophysical Assistants, were created and filled. It was becoming evident, however, that the target fixed was insufficient to meet the demands of a country the size of India, and proposals for a further expansion of the Department to a total cadre of 253 gazetted officers were submitted to the Government of India.

Consequent upon the partition of India during 1947, the Field Circles had to be re-arranged. On the one hand the portion of the Indian sub-continent falling within the new Dominion of Pakistan no longer came within the purview of the Geological Survey of India; while on the other hand a large number of Indian States which acceded to the Indian Union had to be catered for. The number of Field Circles was therefore kept at five, but they were re-arranged as follows:—

NORTHERN CIRCLE .	East Punjab, Himachal Pradesh, Patiala and East Punjab States Union, United Provinces and Bihar.
WESTERN CIRCLE .	Bombay, Saurashtra, Cutch, Matsya, Rajputana and Rajasthan.
CENTRAL CIRCLE .	Central Provinces, Madhya Bharat, Vindhya Pradesh and Orissa.
EASTERN CIRCLE .	West Bengal, Assam and Sikkim.
SOUTHERN CIRCLE .	Madras.

The general plan of organisation of the Department, covering the field season 1947-48, is shown in the chart facing this page, and the report that follows is arranged according to this plan. The map given at the end of the report shows the distribution of the investigations carried out during the year.

---

[1] *Rec. Geol. Surv. Ind.*, 81, pp. 1-222, (1949).

II. GEOLOGICAL SURVEYS

During the year under report geological survey work was carried out in all the five Circles by the respective parties of field workers, each under the guidance of a Superintending Geologist.

NORTHERN CIRCLE

The party working in the Northern Circle, comprising East Punjab, Himachal Pradesh, Patiala and East Punjab States Union, the United Provinces and Bihar, with headquarters at Lucknow, consisted of Dr. M. R. Sahni, Superintending Geologist (in charge), Mr. A. B. Dutt, Geologist, and Messrs. Mukti Nath, F. Ahmad, K. Balu and G. Kohli, Assistant Geologists.

In addition to his duties as Superintending Geologist, involving supervision of field work of the officers attached to the Circle, Dr. Sahni carried out a number of field investigations in connection with the engineering and economic enquiries within the Circle. These are referred to elsewhere.

Bokaro Coalfield, Bihar.

Mr. A. B. Dutt resumed the detailed examination of the Bokaro coalfield at its western end on the new aerial maps (scale 4″=1 mile) and completed the mapping of sheets 1 and 8.

The geological formations met with in the area mapped by Mr. Dutt are as follows:—

3. Post-Gondwana intrusive igneous rocks.
2. Gondwanas—Damudas—
   - Upper—Raniganj stage or Upper Coal Measures.
   - Barren Measures.
   - Lower—Barakar stage or Lower Coal Measures.
   - Talchir stage.
1. Archaean rocks.

The Archaean rocks, consisting mainly of granitoid gneiss, hornblende and mica-gneiss, are traversed by pegmatitic and quartz veins, and are found in the north, west and south of the area surveyed, forming the boundaries of the coalfield in these directions. The Archaean-Gondwana boundary is a faulted one, and a quartzose fault-breccia is occasionally found along the line of the fault.

The rocks of the Talchir stage include a boulder bed and shales, with associated shaly sandstones, both of olive green colour.

The Barakars, the group of rocks overlying the Talchirs, consist usually of coarse-grained sandstones, occasionally false-bedded and at places conglomeratic containing pebbles of various sizes. Bands of shaly sandstones and shales—carbonaceous, micaceous and sometimes ferruginous in minor proportion, and seams of coal of varying thickness and quality, are interbedded with the sandstones. A few of the coal seams are quarried. In some places beds of fireclay are found associated with the coal-bearing rocks, usually underlying the coal seams.

The group of rocks overlying the Barakars is the Barren Measures. They include carbonaceous shales, carbonaceous-micaceous sandy shales, shaly sandstones, sandstones, etc., and contain linear bands and lenticles of clay-ironstones, usually limonitic. The ironstones do not occur in sufficient quantity to be worked economically.

The Raniganj rocks, a small outcrop of which is found east of Taping (23° 50′:85° 30′), consist of medium-grained sandstones and shales and contain a coal seam less than two feet thick. The coal is of inferior quality and the occurrence is of no economic importance.

Dykes of dolerite and intrusions of a siliceous material were noted in the area examined. The dolerite dykes are fairly thick, one being over fifty feet wide, while rocks of the other type rarely exceed two to three feet in thickness.

Jharia Coalfield, Bihar.

Mr. K. Balu commenced field-work early in the third week of November, 1947 and worked with Mr. A. B. Dutt, Geologist, till the end of the month to familiarise himself with field mapping in this area. From the beginning of December, 1947 to the end of February, 1948 he surveyed the western extremity of the Jharia coalfield, confining his attention to the Barakar coal-bearing formations in the Jharia coalfield sheet No. 2 and part of sheet No. 1, scale 4″=1 mile.

The Barakar formation in sheet 2 is encountered between lats. 23° 45′ 5″ and 23° 47′ and between longs. 86° 6′ 5″ and 86° 15′, east of the Jamuni river. The Barakars consist of felspathic sandstones, shales and coal seams, their boundaries being sometimes faulted. There are two sets of intrusive rocks in this area. Mica-peridotites are chiefly found as sills intruding in between the bedding planes of the sandstones and coal seams.

This has resulted in the burning of many coal seams and the formation of *Jhama* or natural coke. Mica-peridotites also occur as dykes. A big dolerite dyke is seen in the eastern end of the sheet.

West of the Jamuni river, in the Karmatand area, the formations are highly faulted, and the coal seams cannot be correlated. Talchir rocks occur in patches to the north, west and south of this area and consist of greenish sandstones, shale and clays. The Barakars are composed of sandstones, shale, carbonaceous shale, a little fireclay and coal seams.

According to Mr. Balu, the Barakar rocks are in contact with metamorphic rocks, Talchirs and the Barren Measures near Dugda Block hut south of Karmatand. Fault rock, which is nearly pure quartz, hornblende-gneisses and some schists characterise the metamorphic rocks. Near Dugda Block hut, a kind of indurated rock is noticed at the Barakar Metamorphic boundary, probably due to a local thrust. Mica-peridotites are common here.

There is an isolated patch of Barakar rocks near Chandrapura. 2½ miles west of Karmatand. Here, the Barakars are gritty and pebbly and the topography is characterised by small hillocks. Patches of Talchir rocks occur and the boundaries of the rocks with the metamorphics are characterised by fault rock. About nine coal seams occur in this area, but their correlation is not easy. Intrusives are practically absent, but there are numerous faults. The rocks dip at relatively high angles compared to those in the area east of the sheet where the dips do not usually exceed ten degrees.

After completing his mapping in the Jharia coalfield, Mr. Balu resumed mapping in sheet 12 of the East Bokaro coalfield on the scale four inches to one mile with a view to gaining experience in detailed mapping.

From the 25th of April to the 19th of May, Mr. Balu resurveyed the Argada (85° 27′:23° 38′ 30″) and Sirka areas, the latter being one mile west of Argada in Sheet 73 E/6.

The area around Argada and Sirka is composed of the Barakars which consist of grits and sandstones. Some ironstones are also found. Coal seams occur interstratified with the grit and sandstones. Bordering the Barakars to the east and north of Argada is a strip of Talchir rocks, showing greenish to greenish maroon sandstones and shales. The South Karanpura coalfield commences about a mile east of Argada (85° 27′:23° 38′ 30″).

The Barakars are faulted to the south against the metamorphics. Bundu Hill, an inlier of metamorphics amidst the Barakars, is seen north of Sirka.

The main seam in Argada is nearly worked out. West of Argada, in the area around Sirka, the lower seams are still unexplored and a large reserve of coal can be expected.

Mandi State, Himachal Pradesh.

Mr. G. Kohli was engaged in mapping the magnetite-sericite-quartzite-schists in the Koti-Kahar area and parts of Mandi State (Himachal Pradesh) in sheet 52 D/16 in connection with the investigation of the possibilities of working the iron-ores (see page 55).

Mirzapur district, United Provinces.

Mr. F. Ahmad mapped an area of about 70 sq. miles in sheets 63 P/3 and P/7 in Mirzapur district, south of the Son, being a southward continuation of the area mapped earlier by Dr. J. B. Auden. According to the existing classification the rocks in this area are referred to the Bijawars, consisting mostly of shales with numerous quartzites, and an intrusive granite. The dips are usually high and uniform and generally towards the south, being sometimes vertical, which suggests isoclinal folding. At the western extremity of the area there are some quartzites, a small thickness of banded-hematite-quartzite, and some marble While the age of these beds is regarded as Bijawars by Mr. Ahmad, this is by no means certain, and the possibility of a part of these being of Dharwar age should not be overlooked.

WESTERN CIRCLE

The party working in the Western Circle, comprising Bombay Province, Saurashtra, Cutch, Ajmer-Merwara, Matsya and Rajasthan, with headquarters at Bombay, consisted of Dr. B. C. Roy, Superintending Geologist (in charge), and Messrs. B. G. Deshpande, B. F. Mehta, B. N. Sinha, T. K. Kurien and K. C. Channabasappa, Assistant Geologists.

Besides inspecting the field work of the members of his party Dr. B. C. Roy attended to a number of engineering, water-supply and mineral enquiries within the Circle, referred to elsewhere.

Ajmer-Merwara.

Mr. B. N. Sinha carried out systematic survey of the mica belt in Ajmer-Merwara in sheets 45 J/12, 15 and 16. The following formations and rock types (not arranged chronologically) have been met with:—

Alluvium.
Talc-schists and serpentine rocks.

Epidiorites. hornblende-schists and amphibolites.

Limestone and calc-silicate rocks with intrusions of tourmaline granite.

Quartzites.

Arkose grits, conglomerates and quartz-mica-schists.

Granites and gneisses with mica-pegmatites and vein quartz.

Schists and phyllites with mica-pegmatites and vein quartz.

As the work concerns Mr. Sinha's first field season's work, the structural relationship of the various formations has not yet been established. This will have to be determined by further detailed mapping covering larger areas.

Mr. Sinha reported on the occurrence of mica-pegmatites in the neighbourhood of Tihari (26° 47′:74° 54′), Tillana (26° 19′: 74° 51′), Ramsar (26° 17′ : 74° 52′ 30″), Sanod (26° 17′ : 74° 50′), Derathu (26° 16′ 30″ : 74° 46′), Loharwara (26° 15′ : 74° 47′ 30″), Kesarpura (26° 15′ : 74° 52′ 30″), Morajhar (26° 18′ 30″ : 74° 55′ 30″). Chandsen (26° 21′ 30″ : 74° 54′), Baneori (26° 26′ : 74° 52′), Dhal (26° 20′ : 74° 48′ 30″), Shokla (26° 13′ : 74° 51′ 30″) and Kalayanpura (26° 14′ 30″ : 74° 53′ 30″). Other economic minerals noted during the survey are referred to elsewhere.

Mr. T. K. Kurien was mostly attached to Mr. B. N. Sinha for gaining field experience in Ajmer-Merwara. Some independent mapping was done by him in sheet 45 J/12, towards the end of the season. The rock types met with are the same as those recorded by Mr. Sinha.

Bijapur district, Bombay.

Mr. B. F. Mehta mapped a part of the Bijapur district in portions of sheets 47 P/7, 11, 12, 15 and 16, comprising the gneissic group. the lower Kaladgis and the Deccan traps.

The gneissic group. consisting of granites. granite-gneisses, chlorite-schists, phyllites, hematite-quartzites, etc., forms the oldest suite of rocks. The granites are occasionally intruded by basic dykes.

The Lower Kaladgi series, comprising quartzites, recrystallised sandstones, ferruginous to saccharoidal sandstones, banded hematite-quartzites, limestones, shales, conglomerates, breccia, grits, etc., overlies the gneissic group. The dips of the lower Kaladgis vary from place to place; part of the area has undergone considerable disturbance, although relatively large tracts remain undisturbed. The Upper Kaladgis are absent in the area mapped.

Considerable portions of the area are occupied by the Deccan traps of compact and vesicular types.

CENTRAL CIRCLE

The party working in the Central Circle, comprising the Central Provinces and Berar, Madhya Bharat, Vindhya Pradesh, and Orissa, with headquarters at Nagpur, consisted of Mr. A. M N. Ghosh, Superintending Geologist (in charge), Messrs. S. Krishnaswamy and P. K. Chatterjee, Geologists, and Messrs. M. K. Roy Chowdhury, A. K. Roy, G. H. S. V. Prasada Rao, S. M. Mathur, K. Narain, Y. G. K. Murty, M N. Deekshitulu and G. V. Rao, Assistant Geologists.

Mr. Ghosh was mostly engaged in the initiation into and supervision of the field-work of the various members, particularly the junior officers, of his Circle.

Balaghat district, Central Provinces

Mr. M. K. Roy Chowdhury mapped a portion of the Topla and neighbouring highlands of the Balaghat district included in sheets 64 B/16 and F/4.

Phyllite and mica-schist, with bands of dolerite and amphibolite, are well-exposed in areas not covered by laterite. Intrusive granites, mostly pegmatitic, are quite common. Gritty siliceous limestones are occasionally exposed at the base of the trap, boulders of the latter being commonly observed on the slopes of the laterite-capped ridges between altitudes 2250 to 2500 feet. West of Garhi (22° 13′:80° 48′) trap is found even on the peak 2774. Here the boundary of trap and laterite runs E.N.E.-W.S.W. along a well defined line.

Nagpur district, Central Provinces.

Mr. P. K. Chatterjee examined the exposures of the Lower Gondwana rocks, represented by Kamthis, in the Katol-Saoner area of the Nagpur district. Broadly speaking there are three separate exposures of the Kamthis. One extends N.W.-S.E. over a distance of about 25 miles from Kelod (21° 28′: 78° 47′) to Kanhan (21° 13′:79° 14′) and consists of coarse grained dark brown sandstones, dark brown felspathic grits and thin bands of fine-grained and compact argillaceous red sandstones. The rocks are mostly concealed under alluvium and have variable dips up to 45°. The two other occurrences are near Chorkheri (21° 27′:78° 40′) and Bazargaon (21° 08′:78° 02′), where they form inliers in the Deccan trap. The Chorkheri inlier stretches N.W.-S.E. over a distance of about three miles, with a maximum width of two miles at the centre. The beds dip to the north-east at 8° and consist of fine-grained red and yellow argillaceous sandstones occasionally interbedded with coarse grained soft felspathic sandstones. South-west of Shemda

(21° 27′:78° 42′) a greyish-white fine argillaceous sandstone, underlying red sandstone, showed impressions of plant remains resembling *Glossopteris* fronds. The Bazargaon inlier stretches E.-W. along its length for nearly eight miles and is five miles broad. The beds are generally rolling and have low dips as a rule, although dips as high as 20° are noticeable at places. The sandstones have the same lithological features as the other two exposures.

Raigarh State, Central Provinces.

Towards the end of the field-season Mr. S. M. Mathur spent a few weeks in mapping the area surrounding Raigarh town (21° 53′:83° 24′) included in sheet 64 0/5. The basement complex consists of granite-gneisses intruded by basic dykes and rarely by pegmatites, and it is unconformably overlain by (?) Lower Vindhyan purple and green shales mostly calcareous, fine-grained bedded sandstones and variously coloured quartzites. The Vindhyans are contorted and overlain by Lower Gondwana beds represented by Talchir greenish shales and fine grained buff and green sandstones, white or dark red, massive Barakar sandstones and porous, white Kamthi sandstones. Disconnected blocks and boulders of basaltic rocks were found scattered over Vindhyan shales in several localities. Their age is uncertain. Mr. Mathur also paid a visit to Kharsia (21° 59′:83° 7′) where the rocks met with are similar to those near Raigarh town.

Wardha Valley, Chanda district, Central Provinces.

Mr. S. M. Mathur was also engaged in the systematic mapping of the Wardha Valley coalfield, Chanda district, included in sheet 56 M/5. The area is occupied by Lower Gondwana formations represented by the Talchirs, Barakars and Kamthis. The Talchirs are exposed in small, widely separated outcrops mostly in the tract west of the Erai river. The basal beds consist of pebbles and boulders of limestone, granite, quartzite, chert and jasper embedded in a hard, compact, sandy matrix. Silty shales greenish in colour and deep buff and yellow sandstones constitute the other members of the Talchir series.

The Barakars are represented by felspathic, whitish sandstones associated with coal seams. The sandstones are compact and fine to coarse grained in texture. Specks of carbonaceous matter are occasionally seen. Weathered surfaces of Barakar sandstones show a characteristic nodular appearance. The nodules are calcareous in composition. Both the Talchirs and the Barakars have low dips not exceeding 15°.

The Kamthis occupy the major portion of the area and consist of porous and coarse-grained white sandstones as well as gritty, ferruginous and compact dark coloured sandstones. As a rule there is an absence of distinct bedding in these sandstones. Fine-grained, argillaceous, thinly bedded, white and pink coloured sandstones also occur and have yielded plant remains. The dips are variable. The Kamthis also contain red and yellow ferruginous shales which occur in small outcrops within the sandstones.

Athmallik State, Orissa.

Mr. S. C. Chakravarty was attached to the geophysical party, engaged in the investigation of graphite at Dandatapa (20° 43′: 84° 36′), Athmallik State, Orissa. He made a detailed geological survey of the area under geophysical exploration for graphite, and prepared a geological map of the area on a scale of 1 mm.=1 metre. The area surveyed was about 600,000 sq. metres, and electrical readings on about 3,000 stations were recorded.

The area is occupied by rocks of the Khondalit suite represented by garnetiferous-sillimanite-schists with flakes of graphite, quartzites. diopside-granulites and garnet-gneisses. The rocks strike more or less in N. 10° W.-S. 10° E. direction and dip at 45° to 80° towards east. They are intruded by granitic rocks. Some pyroxenites and amphibolites are also present.

Koraput district, Orissa.

Mr. G. H. S. V. Prasada Rao and Mr. Y. G. K. Murty were engaged in the mapping of sheets 65 M/14 and M/15 covering a portion of the Gunupur *taluq* of the Rayagada sub-division. The gaps left by previous workers in this area have now been filled in.

The oldest rocks of the area are the khondalites, outcrops of which are of varying dimensions and usually restricted to the summits and flanks of the hill ranges. Outcrops of khondalite. nearly four miles long and one mile broad, occur between Chandrapur (19° 36′:83° 53′ and Pukura 19° 40′:83° 49′). The khondalits weather into characteristic conical peaks and rugged precipitous cliffs. The rocks are intruded by granitic and basic materials, sometimes in a *lit-par-lit* fashion.

Charnockites of the area are generally represented by the acid and intermediate varieties. The rocks are mostly granular but sometimes porphyritic and grade into the surrounding granites and gneisses. An outcrop of basic charnockite nearly two miles long and of appreciable width is present south-east of

Odengi (19° 41′ : 83 52′). The rock has been intruded into khondalites, and pleonaste is found near the contact. Numerous basic bands of either hypersthene-norite or hypersthene-granulite are present throughout the area. They occur as small bands or lenses both as inclusions in granites and charnockites as well as minor intrusions in khondalites. At Puruduguda (19° 31′: 83° 51′) they were found intruded into the granites.

By far the most widespread rocks are granulites and granite-gneisses which have escaped foliation at some places. There are several varieties of granite-gneisses of which the chief is a porphyritic type, sometimes garnetiferous. The porphyritic granite is the most prevalent type and bears an intrusive relationship to all the older rocks. It forms bare hill masses sometimes rising 1,000 feet above the surrounding country. The granulites are both massive and streaky. When streaky and garnetiferous, the granulites can be designated as leptynite. Some of the granulites and leptynites, especially those near large masses of porphyritic granites, are characterised by the presence of felspar phenocrysts. There are also instances of porphyritic granite alternating with non-porphyritic granulite. In the vicinity of the exposures of khondalite, the granulites are faintly banded and contain sillimanite.

General profiles across the area show two peneplanes, one at 1,000 feet and the other between 2,000-3,000 feet above the sea level, suggesting two periods of upheaval.

Three directions of jointing aligned N.E.S.W., N. 10° W.S. 10° E. and E.W. are present and have influenced the water courses of the area.

Sambalpur district, Orissa.

Mr. S. Krishnaswamy introduced Mr. Kedar Narain to the geology of a part of the area around Bargarh (21° 20′:83° 37′) contained in topo sheet 64 0/11. Mr. Kedar Narain mapped a portion of the sheet included within latitudes 21° 15′ and 21° 26′ and longitudes 83° 30′ and 83° 45′.

The oldest country rocks appear to be quartz-mica-schists and quartzites constituting the low hillocks lying at the south-east corner of the sheet. The rocks strike N.-S. and have high westerly dips.

The rest of the area is occupied by granite-gneisses showing a wide variation in texture and composition. At some places the direction of the foliation of the gneisses is N.N.E.-S.S.W. Coarsely crystalline unfoliated, porphyritic biotite-granites also occur. The gneisses are traversed by basic dykes represented by amphibolite and epidiorite. Numerous thin veins of quartz and pegmatite intrude into the gneisses, generally along the foliation of the latter. At several places small patches of laterite are present.

Datia State, Vindhya Pradesh.

Systematic mapping of the Datia State territories included in sheets 54 K/N.W., K/N.E., K/S.W., J/S.E., N/S.W., and O/N.W., was carried out by Mr. M. K. Roy Chowdhury.

The major portion of the State is covered by thick alluvium. Bundelkhand gneisses traversed by quartz reefs and dolerite dykes occupy Datia town and the southern portion of the State. In the plateau region north of the Sind river in the Seondha *tahsil* quartzites and shales of the Gwalior series are present. The lower stage of the Gwalior series, known as the Par group, is represented by ferruginous sandstone and semi-quartzite with thin intercalatious of hematite shales. The upper stage, known as the Morar group, is composed of ribboned shales with siliceous concretions and bands of hornstone. A variegated calcareo-siliceous rock is observed at the base of the Morar group near Bara Ratangarh (26° 10′:78° 39′).

Maihar State, Vindhya Pradesh.

Mr. G. Venkateswara Rao was engaged in the survey of Maihar State, Central India. The area is included in sheets 63 D/11 and 15, 63 D/12 and 16, 63 H/4 and 8 and 64 A/5. The State is occupied by almost all the stages of the Vindhyan system consisting of alternate bands of shale and limestone in the lower portion and mostly sandstones in the upper. The Lower Vindhyan shales and limestones are moderately folded and they dip at 20° to 30° towards N. 10° W. The upper Vindhyans have gentle dips in the same general direction as the Lower Vindhyans.

EASTERN CIRCLE

The party working in the Eastern Circle, comprising West Bengal, Assam and Sikkim, consisted of Dr. A. K. Dey, Superintending Geologist (in charge), and Messrs. D. K. Chandra, B. Laskar and T. Banerjee. Assistant Geologists.

Examination of mineral occurrences of economic interest and investigation of the problems of engineering geology and water-supply occupied most of the time of the members of the party, and little systematic mapping was carried out in the Circle.

Sibsagar and Nowgong districts, Assam.

In the course of his investigation of limestone occurrences in the Mikir hills, Mr. D. K. Chandra carried out systematic geological mapping of the areas roughly bounded by latitudes 25° 45′, 25° 52′. and longitudes 93° 10′, 93° 22′ 30″, and by latitudes 25° 52′, 26° 05′, and longitudes 93° 10′, 93° 20′, comprising parts of sheets 83 G/1, 2, 5 and 83 F/4 and 8, the area mapped falling partly in the Sibsagar district but mainly in the Nowgong district. The mapping was in continuation of the work of Messrs. P. N. Mukherjee and V. R. R. Khedkar during the 1940-41 field season. The geological formations met with were:

Alluvium (Recent)
Tipams
Surmas
Nummulitic limestone (Sylhet limestone)
Quartzite, Quartzitic Sandstone, Grit
Sandstone (Cherra sandstone)
Trap (Sylhet trap)
Granite
} Tertiary.

Except for local minor folding and faulting, no major post-Tertiary tectonic upheaval has been noted in the area mapped. The Tertiary strata are generally rolling or horizontal. The different series of Tertiary formation are apparently almost conformable, except for slight erosional unconformity here and there. The rocks of the Surma and Tipam stages are often so alike that the boundary can only be drawn with difficulty. The Tertiary beds are rather high-dipping; this may be due either to the shore-deposition factor or wrinkling up of the soft younger Tertiary beds overlying the granite.

The sandstone referred to the Cherra sandstone stage contains lignitic or shaly coal, an account of which is given under Mineral Investigations.

The quartzite, quartzitic sandstone or grit bed exposed along the Paklangso *nala* and the Meyong Disa may either belong to the Cherra sandstone stage or may be the basal stage of the Nummulitic limestone. The fossils indentified by Mr. P. N. Mukherjee from the Nummulitic limestone include *Venericardia mutabilis, Ostrea sp., Assilina cf spira* and *Nummulites cf obtusus* and indicate a Kirthar age.

The Tipams, which cover the major portion of the area mapped, have yielded silicified woods which are being studied by Dr. K. Jacob, Palaeobotanist of the Department.

SOUTHERN CIRCLE

The party working in the Southern Circle, comprising Madras Province and the Madras States, with headquarters at Madras, consisted of Dr. M. S. Krishnan, Superintending Geologist (in charge), Messrs. N. K. N. Aiyengar, M. S. Venkatram and V. Subramaniam, Geologists, and Messrs. S. Narayanaswami, A. P. Subramaniam, A. K. Belgaumi, S. N. Sen, Mohd. Ziauddin, C. Ramaswamy, N. V. Chandrasekariah, R. Thiagarajan, N. V. B. S. Dutt, A. S. Ramiengar, V. Venkatesh. B. Srikantan, J. Narayanamurthy and V. Gopal, Assistant Geologists.

Dr. Krishnan paid two visits of inspection, the first to the Sithampundi corundum belt in the Salem district where Mr. A. P. Subramaniam, Assistant Geologist, was working; and the second to the West Godavari district where Messrs. C. Ramaswami and Mohd. Ziauddin, Assistant Geologists, were introduced to the local geology. In the Sithampundi area, interesting questions relating to the origin and inter-relationship of the anorthite-gneiss, amphibolite, pyroxene-gneiss, etc., were studied, since they contain workable deposits of corundum and chromite.

Anantapur district, Madras.

Mr. R. Thiagarajan mapped in detail, with particular reference to minerals of economic importance, portions of the Tadpatri *taluk*, Anantapur district, on standard sheets 57 E/16, F/13 and 1/4. The following is the sequence of rock formations in the area traversed in the Tadpatri *taluk* :

Kurnool . .	Paneum . .	Plateau quartzites;
	Jammalamadugu . .	Owk shales; Narji limestones and flags.
	Banganapalle . .	Sandstones and conglomerates;
Cuddapah . .	Cheyair . . .	Tadpatri shales and slates, Pulivendla quartzites;

The Pullivendla stage is composed of fine-grained, compact, pink to grey quartzites and conglomerates. These constitute the hillocks and ridges to the west of Kesavanayanipeta (57 E/16—77° 48′ 45″:15° 6′ 30″), Chandana (57 E/16—77° 49′:15° 4′ 45″), Rayalacheruvu (57 E/16—77° 49′:15° 3′ 15″), Kottapalle (57 E/16—77° 49′:15° 2′), half a mile E.N.E. of Chinnapappuru (57 F/13—77° 52′ 15″:14° 56′), N. and S. of Chikkepalle (57 F/13—77° 52′: 14° 53′ 15″) and Mutssukota (57 F/13—77° 52′ 30″:14° 51′) and N.W.N., W. and S. of Dosaledu (57 F/13—77° 54′ 30″:14° 46′ 45″).

Further eastward, however, the Tadpatris, composed mainly of shales and slates, underlie the entire tract. The general strike of the formations is N.N.W.-S.S.E. to N.N.E.-S.S.W. (dip 10° to the east). The following types make up the stage:

1. *Calcareous grey and sometimes purple shales.*—These are not exposed on the surface but are seen in debris from wells at Lakshumpalle (57 E/16—77° 49′ 30″: 15° 7′), Chandana, Dharmapuram (57 F/13—77° 53′: 14° 55′ 15″), Varadayapalle (57 F/13—77° 52′ 45″: 14° 52′ 15″), Kondapuram (57 F/13—77° 54′ 30″: 14° 51′ 45″), Middepalle (57 F/13—77° 56′ 15″: 14° 45′ 15″), etc.

Intercalated thick beds of grey, siliceous, finely crystalline limestones are noticed at the western flanks of the hills to the east of Lakshumpalle and E.N.E. of Srinivasapuram (57 E/16—77° 50′: 15° 5′), W. of Thimmancheruvu (57 F/13—77° 53′ 30″: 14° 56′ 15″), Somanapalle (57 F/13—77° 53′ 30″: 14° 54′ 45″), Kondapuram, etc. These rocks are often masked on the surface by soil containing tufaceous *kankar.*

2. *Red and purple slaty shales with intercalated beds of ferruginous and jaspery shalés.*—These are straitigraphically above the calcareous shales and are extensively quarried as building stone. These make up the hills and high grounds to the W. and N.W. of Kona Uppalapadu (57 E/16—77° 54′: 15° 6′), W. of Obulapuram (57 E/16—77° 53′ 30″: 15° 5′ 45″), S.E. of Juturu (57 F/13—77° 54′ 45″: 14° 56′ 30″), etc.

3. *Brown and grey and purple slaty shales with intercalated flaggy quartzites.*—These succeed the above mentioned ferruginous and cherty shales. They are well seen at the western and southern flanks of the Kavulapalle (57 E/16—77° 56′ 55″: 15° 7′) plateau.

The Tadpatri shales are often traversed by trap sills which form the tops and eastern slopes of the ridges, while the underlying shales form the steep western flanks.

The Kavulapalle plateau is fringed on the west and south by a thin formation of well-bedded greyish white, medium to fine-grained sandstones of the Banganapalle stage overlying the brown and grey shales of the Cheyairs unconformably.

The Jammalamadugu stage consists of thick bedded, fine grained and compact limestones of different colours with intercalated beds of grey flags. These rocks make up the entire plateau on which stand Kavulapalle and Gudipadu (57 E/16—

77° 59′ 30″: 15° 5′ 45″). They are succeeded by thin-bedded brown slaty shales which are typically seen at the southern and south-western slopes of the Burugala (57 E/16—77° 57′: 15° 8′ 15″) plateau.

Hard, compact and vitreous quartzites of the Paneum stage make up the Burugala plateau.

North Arcot district, Madras.

Mr. B. Srikantan geologically mapped about 400 square miles comprising sheet No. 57 0/8 and the eastern part of sheet No. 57 0/4. The area lies in the northern part of the Walajah taluk, North Arcot district; the south-western part of the Tirutani taluk and the eastern part of the Chittoor taluk of the Chittoor district.

The rock types constituting this area are biotite-gneiss, pink quartzo-felspathic gneiss and dolerite. The former two rock formations contain patches of hornblende-gneiss, amphibolites, biotite-schist and talc-rock. The hornblende-gneiss is usually associated with hematite-quartzite.

Biotite-gneiss.—Forming a part of the Peninsular gneiss, this rock type reveals a number of variations as regards its texture and composition. But these variations are often very gradual and rarely discernible. The biotite-gneiss generally consists of biotite, quartz and felspar (mostly orthoclase). These constituents vary, and there are rock types which are almost wholly composed of biotite and others which are almost entirely of quartz and felspar, with very little or no biotite. The felspar is generally orthoclase and the pink variety occurs sporadically distributed in the rock. This gneiss varies from a very fine grained almost schistose type to a very coarse and porphyroblastic type. It is not possible to demarcate between these types. The gneiss has a foliation direction of N. 10° E. which, however, is variable and swings between N. 10° E. and N. 10° W. The gneiss often occurs as bosses occupying the summits of hills. It also reveals signs of crushing and shearing, which is clear on the hills west of ·1275, west of Gangadharanellore (79° 11′: 13° 14′), where the quartz constituent has been rolled out into pebbles.

Pink quartzo-felspathic gneiss.—This is characteristically composed of pink orthoclase felspar and quartz; it is rather granitic, coarse and often almost like pegmatite. Irregular patches of this occur north-east, north and north-west of Sholinghur. It also constitutes the hillocks two miles west of Vediyangadu Kotturu (79° 20′: 13° 6′).

Both these rock types contain inclusions of hornblende gneiss (granulite), biotite-schist and talc-rock. The inclusions of hornblende-gneiss occur as lenticular patches drawn out in the direction of foliation of the major rock, and consist of hornblende and felspar, with a schistose structure. The small inclusions are innumerable, but a few of them attain great sizes, like the one north-west of ·786, 1½ miles N.W. of Nochchili (79° 28′ 30″:13° 14′) and the hill 1789 (S. of Panattur) (79° 8′ 30″:13° 3′ 30″) which are composed of this rock showing a foliation direction of N. 5° E., and dips rather steeply to the east. Large patches of the hornblende-gneiss are usually associated with hematite-quartzite which occurs as small elongated lenticles, well banded, and rarely more than a few feet in extent.

Talc rock (steatite).—It occurs as a wide patch in the biotite-gneiss and consists of impure, siliceous talc, east of Gangadharanellore, extending up to Narasingarayanpet (79° 12′ 30″: 13° 10′ 30″). This is associated with hornblende-granulite or amphibolite. Hill △ 1645 south of Karasingarayanpet is almost entirely composed of this rock type.

Quartz veins and reef.—A large number of quartz veins occur sporadically, but they rarely exceed a few feet in length. East of Advamanubodu, (north of Mahadevapuram) (79° 22′ 30″: 13° 12′) a quartz-vein about 25 feet wide runs N. and S. for nearly three furlongs ; two miles N.N.E. of Narasimhapuram a narrow quartz-vein has developed druses containing quartz crystals. On the western flank △ 1645 is highly sheared quartz vein.

The quartz reef observed on the hills west of Ammur (sheet No. 57 P/5) continues to the north-west on to the top of the hill ·1269 and beyond to ·797 west of Jambukolam (79° 23′:13° 2′ 20″) where it thins out. This reef is more than 75 feet in width at places and runs for more than three miles. It is well jointed and the quartz is transparent to opaque, and generally tinted green.

Dolerite Dykes.—A large number of basic dykes run across the other formations. Their directions vary from east-west to north-south. They also range from very fine grained almost basaltic types to very coarse grained types, with porphyritic felspars.

The geological sequence of the area is as follows:

4. Dolerite dykes.
3. Pink quartzo-felspathic gneiss.

2. Biotite-gneiss, quartz veins and reefs.
1. Biotite-schist, hornblende-gneiss probably Dharwar, calc-rock, hematite-quartzite.

East Godavari district, Madras.

Systematic mapping was carried out by Mr. C. Ramaswamy in parts of the East Godavari district included in the sheets No. 65 G/15 and 65 G/16. The general succession of the geological formations worked out in this area is as follows:

Rajahmundry sandstone.

- -

Deccan traps with inter-trappean limestone.

Bezwada gneiss or garnetiferous gneiss with intrusive or associated rocks.

Bezwada gneiss.—The Bezwada gneiss, consisting essentially of garnetiferous gneisses, occupies an extensive area stretching from south of Koru Konda (65 G/16—17° 10′ 15″:81° 49′ 30″) to the north of Rampa (65 G/15—17° 27′ 30″:81° 46′ 45″). It forms prominent ranges of hills in these areas. The gneisses are composed essentially of quartz, felspars and micas, and are crowded with grains of garnets. The felspars are mostly orthoclase and they are more or less kaolinised. Micas, both muscovite and biotite, occur in the form of minute flakes and scales, but usually muscovite predominates over biotite. Garnet always occurs in the form of rounded grains varying in size from minute grains to grains as big as pea nuts, and they are either pink or reddish brown in colour. Veins of coarse pink felspars and quartz are often seen running through the garnetiferous gneisses.

The strike of the formations is variable between N.E.-S.W. and N.N.E.–S.S.W. The dip is generally high, ranging from 70° to 80°.

Associated rocks.—These rocks show great variation both in their mineral composition and in their texture. At one place the rock is composed of quartz, felspar and biotite without garnet and it is granular and massive. In another area, the rock is composed of quartz, felspar and biotite with but traces of garnet, and it shows gneissose structure. In another area, the rock is coarse grained and it is composed of quartz, felspar, biotite and garnet, with large crystals of greyish white shining felspars occurring as phenocrysts which measure about one to one and a half inches in length and one quarter to half an inch in width.

Deccan traps.—The traps occurring to the east of the Godavari near Rajahmundry are exposed beneath alluvium in many of the quarries, but in a few places they are exposed at the surface. They gradually thin out towards Rajanagram (65 G/16—17° 4′ 45″ : 81° 54′ 0″) in the west. In some places the traps are hard, compact, fine-grained and non-vesicular, while in some other places they are less compact and are minutely vesicular.

Inter-trappean limestone.—There are two thin bands of inter-trappean limestone occurring associated with the traps. One narrow band, about two miles in length, is exposed at a place about three and a half furlongs south-east of Kuntamuru (65 G/16—17° 3′ 0″ : 81° 47′ 45″) as also about one mile south-east of Kotta-Kolamuru (65 G/16—17° 3′ 48″ : 81° 48′ 45″). Its continuation can be seen near the Tuberculosis Sanatorium where numeros old quarries are present. It has a width of about 30 or 40 feet, as exposed in the quarries. They are massive and buff coloured.

Rajahmundry sandstone.—The Rajahmundry sandstones cover a fairly large area in East Godavari, stretching from Rajahmundry to Narasimhapuram in the north and to Dontamuru in the east. They consist of conglomerates and sandstones which rest unconformably over the Deccan traps. The sandstones show current bedding prominently. The general strike of the sandstones is N.E.-S.W. and they dip at 10° to 15° towards the south-east.

West Godavari district, Madras.

Systematic mapping of an area of about 400 square miles was carried out in the Kovvur and Polavaram *taluks*, West Godavari district by Mr. Mohd. Ziauddin.

The different rock types met with in the area in the course of systematic mapping are as follows:

Rajahmundry sandstone.

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Traps with inter-trappeans.

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Infra-trappeans.

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Tripati sandstone.

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Gollapili sandstone.

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Chintalpudi sandstone.

Quartzose gneiss.

Charnockite series.

Garnetiferous gneiss with associated intrusives. calc-gneiss and crystalline limestone.

Magnetite-quartz-gneiss.

Magnetite-quartz-gneiss.—These and the calc-gneisses and limestones are probably the oldest rocks of the area. The mineral constituents are quartz, felspar and magnetite; but sillimanite also makes its appearance and is sometimes in fair abundance. They are folded into fairly sharp folds and the dip is generally high.

Garnetiferous gneiss with associated intrusives, calc-gneiss and crystalline limestone.—These rocks occupy a fairly large area and are closely associated with magnetite-quartz-gneiss. The garnetiferous gneisses are composed of quartz, felspar and garnet and occasionally biotite, tourmaline and graphite. Veins of quartz and felspar having perfect cleavages were noticed cutting across this gneiss. The weathered rock simulates a ferruginous sandstone. The general strike-direction is found to vary from N.W.-S.E. to N.E.-S.W.; but everywhere the dip is high (70°-80°).

The garnetiferous gneiss is found to be intruded by both mica-bearing and barren pegmatite veins. Further, showing a somewhat intrusive relationship with the garnetiferous gneiss, is found a rock composed of quartz, felspar and augite exhibiting spheroidal weathering.

Calc-gneiss is often a frequent associate of garnetiferous gneiss as also of the quartzose gneiss to be described later. In this rock quartz is predominant with some felspar and calcite. Some calc granulite and crystalline limestone are also noticed.

Charnockite series.—All varieties from acid to basic are represented. Sometimes garnet and well-developed orthoclase felspar are seen in the rock. Some of the hill masses which are entirely composed of these and other related rocks such as leptynite and norite are poorly covered with vegetation.

Quartzose gneiss.—This rock is noticed south and west of Polavaram resting over the garnetiferous gneiss. The rock reveals abundant quartz and a little felspar which is highly altered. The gneissic texture is not usually well developed, the rock then appearing massive. The quartz is fine-grained and sometimes entirely glassy.

Pegmatite veins intruding into mica-schist have been noticed in the metamorphic area south of Polavaram. The mica of the pegmatite is muscovite. From one vein a book of mica was collected which was 16 square inches in area and one and half inches thick.

Chintalpudi sandstone.—Overlying unconformably the metamorphic series are seen a group of purple brown ferruginous sandstones and clayey beds. The group is about 80 to 120 feet thick, dipping at low angles to the south. Doubtful plant-remains were noticed in clays dug out of wells at Koyyalagudem 17° 6′ 30″: 81° 26′).

Gollapilli sandstone.—These are a set of sandstone, grit and conglomerate generally dark-brown to yellowish red dipping gently to the south.

Tripati sandstone.—These overlie the Gollapillis and cover a large area. They are brown and reddish sandstone having gentle dips to the east.

Infra-trappean bed.—This is represented by a set of calcareous sandstones seen lying unconformably below the traps, with a gentle E.N.E.-W.S.W. strike and a low dip. They are soft sandstones containing gastropods and other fossils.

Traps with inter-trappeans.—The traps form flat-topped hill masses and are about 250 feet thick, fine-grained, sometimes medium-grained and occasionally scoriaceous. They cover a large area near Pangadi (17° 1′:81° 39′) and include an inter-trappean bed of limestone. The latter is about 20 feet thick and is composed of layers of variable composition.

Rajahmundry sandstone.—These are the youngest rock types, overlying the traps, composed mainly of sandstone with a few conglomerate and gritty beds. The dip is to the south, generally very low, seldom more than 8°-10°. They are brown coloured generally soft and show current bedding very well.

West Godavari District, Madras.

Mr. M. S. Venkatram introduced Messrs. C. Ramaswamy and Mohd. Ziauddin to the geology of a part of the West Godavari district. The area between Pangadi (65 G/12-17°1′ : 18°39′) and Duddukuru (65 G/12-17°2′ : 81°36′) in the west, and Gopalapuram (65 G/12—17°6′ : 81° 33′) in the north was mapped.

The formations met with in the area mapped, in the descending order of succession are:

Rajahmundry sandstones,

Deccan traps, with a band of inter-trappean limestone,

Infra-trappean sandstones,
Tripety (Tirupati) sandstones, and
Golapilli sandstones.

All these formations have a general gentle dip towards the south or south-east.

Kistna district, Madras.

Dr. Krishnan examined the mica-pegmatites in numerous places in the Tiruvur *taluk*, Kistna district, Madras. The country rocks are biotite-muscovite-gneisses with a N.E.-S.W. strike traversed by pegmatite and quartz veins. There is generally a soil cover of 2 to 5 feet in the plains, but the presence of pegmatite is revealed by fragments of felspar and flakes of mica.

Guntur district, Madras.

Mr. N. V. Chandrasekariah carried out mapping in the Guntur district, on sheet 56 P/16. The main rock types in this area are phyllites, quartzites, granite-gneisses and charnockites. Inclusion of basic rocks such as dolerites, amphibolites, hornblende-schists, etc., are also common.

The phyllites occur in the north-west corner of the sheet, forming the plains and lower horizon of the hills, while the quartzites form ridges.

Granite-gneisses are the most widespread in the area. They show two major systems of joints, one of which strikes N.-S. to N.N.E.-S.S.W. and the other E.-W. to E.S.E.-W.N.W. The dips are southwards. The gneisses are partly banded and partly foliated and very commonly garnetiferous.

The hills in the south-east corner, round about Kommalapadu, are mostly constituted of charnockites and granites in varying proportions. The hillocks to the east and south-east of Basavaripalem are composed of hybrid gneisses where the various stages of mixtures of charnockites and the invading granite are clearly seen. The charnockites are the older suite of rocks as evidenced by the presence of xenoliths of charnockites in the granitic masses.

The dolerites occur mostly in the south and south-eastern parts in the form of rounded of irregular bodies, exhibiting characteristic spheroidal weathering.

There are numerous quartz and a lesser number of pegmatite veins, running parallel to the foliation-planes of the gneisses and schists and sometimes cutting across them.

Guntur, Nellore and Kurnool districts, Madras.

Systematic geological mapping of the Archaean rocks in the Guntur and Nellore districts and along the border of the Guntur and Kurnool districts was carried out by Mr. S. N. Sen.

An area of 615 square miles was covered during the field-season, comprising the major portion of Vinukonda *taluk* of the Guntur district and the Darsi *taluk* of the Nellore district, in Sheets Nos 56 P/12, 56 P/11, 56 P/16, 57 M/6 and M/13.

In the northern area phyllite and quartzite form the predominant rock-types. Phyllites constitute most of the hillocks, with occasional bands of quartzites and quartz veins. Proceeding south-west quartzites are more prominent and constitute the hillocks, Chidarakona (932), Edlurukonda (·977) Naddikonda, etc., of sheet No. 56 P/12. In some cases, as for example Yerrakonda (△ 1142, ·838,—56 P/12), the hillocks are composed of phyllites, but numerous quartz-veins and thin bands of quartzites are met with, running on the ridges. The strike of the country rocks varies from N.N.E.-S.S.W., to N.E.-S.W., in general. Dips vary from 32° to 60° to the E.S.E. to S.E.; inclinations of the outcrops on the opposite directions are also noted.

In the southern area granite and charnockites form the most prominent rock types. In the Gundlakamma river and Val Eru stream, and on the plain around Ainavolu (15° 59′ 30″:79° 40′ 10″ —57 M/9), exposures of hornblende-schists and granites are quite common. Exposures of amphibolites, hornblende-schists with granite intrusions, and gneisses formed out of hornblende-schists being largely intruded by granitic bodies and disturbed and contorted are quite common along the Val Eru and Gondlakamma streams. Outcrops of amphibolites intruded by pegmatites are noted east of Nadigadda tank bund, about 10 furlongs S.E. of Gondapadu (16° 4′:76° 39′ 30″—56 P/12).

Hillocks, Torakonda (·900), ·704 hillocks, Nallakonda (·714), Gurapadu (·647), etc., situated about four miles W.S.W. to S.W. of Nujendra (15° 55′ 40″:70° 44′ 30″—57 M/9) are composed of granites and gneisses. South-west of Mudlamuru (15° 49′: 79° 50′ 20″—57 M/13), charnockites occur as boulders and hummocky masses over a wide area. Here both coarse and fine-grained varieties of charnockites are found. Dolerite dykes are found on the plains as well as in the river sections. The stike of the country rocks varies from N.N.W.-S.S.E. to N.E.-S.W., in general. Dips vary from 40° to 55° between W.S.W. and S.E.

Kurnool district. Madras.

Mr. Venkatram examined some portions of Koilkuntla and Nandikotkur *taluks*, Kurnool district, included in parts of sheet Nos. 57 I/7, I/8, I/1 and I/5, to correlate the work of Messrs. N. V. B. S. Dutt and V. Venkatesh, Assistant Geologists, who had been carrying out systematic geological mapping in the region. The area examined consists mainly of horizontally disposed dark grey calcareous flags overlain by purple calcareous shales belonging to the Kundair group of the Kurnool series.

Mr. N. V. B. S. Dutt carried out systematic mapping of the Kurnool series in Koilkuntla and Banganapalle *taluks* of Kurnool district on sheets 57 I/4, J/1, E/16, I/8, J/5 and I/7. A portion of Jammalamadugu *taluk*, Cuddapah district, comprising the area to the north and east of Errakonda in 57 I/8 was also mapped.

A provisional sequence of the formations of this area is given below:

Series.	Stages.	Rock types.
Kurnool	Kundair	Limestones and calcareous shaly flags;
	Paniam	Quartzites and sondstones;
	Owk	Calcareous flags and shales;
	Narji	Massive limestones with thin basal beds of shales and calcareous flags; Occasional basal conglomerate;
	Banganapallo	Quartzites, sandstones and conglomerates.
Cuddapah	Nallamalai	Quartzites;
	Cheyair	Shales.

The Nallamalai quartzites, the oldest rock type seen in this area, occur as inliers for the most part in Narji massive limestone, forming low mounds in the south of sheets 57 I/4 and I/8 and in 57 J/1 and J/5. They are fine-grained, hard and compact, and pinkish and greyish in colour. They are well jointed and exhibit current-bedding at some places. Associated with these quartzites are seen thin-bedded, pinkish brown shaly sandstones.

Nallamalai quartzites are in contact with Banganapalle quartzites at the district boundary between Korumanipalle (57 J/1—78° 6′ 45″:14° 59′ 45″) and Urachintala (57 J/1—78° 5′ 40″:

14° 56′ 40″). Here the unconformity is marked by a conglomerate of small, rolled and flattened quartzite pebbles of castor seed size and shape in a quartzitic matrix. Elsewhere, however, Narji massive limestones overlie the Nallamalais unconformably.

Banganapalle quartzites and sandstones, the basal members of the Kurnool series, are exposed overlying the Cheyair shales in the south-west corner of sheet 57 I/4 and continue for some distance in sheets 57 J/1 and E/16 along the district-boundary. They are medium-grained and greyish in colour and often weather to buff-brown or reddish brown on the surface. They are thick bedded and jointed and exhibit current-bedding. The basal conglomerate is very irregular and is absent over long distances.

The Banganapalles pass upward into Narji massive limestones through thin beds of calcareous shales and flags.

Narji massive limestones are bluish grey in colour with jointing along bedding planes at intervals of four to six inches and even wider. They exhibit an intricately rugged surface on weathering and give rise to black soil.

The Narjis are followed by calcareous flags, argillaceous in varying degrees and forming the wide stretch of flat country of sheets 57 I/4 and I/8. They are grey and are capable of yielding one to two inches thick slabs of bedded slaty limestones close to the boundary of massive limestones. But away from the bounadry they become more and more argillaceous and weather into thin plates with a superficial buff colour.

Paniam quartzites and sandstones build the flat tops of the hills and plateau of sheet 57 I/4. They are medium-grained and slightly pinkish in colour and show imperfect alternation of bands in pink and white, by virtue of which current-bedding is exposed in a striking manner. They are less hard than the Nallamalais or the Banganapalles, the former being the hardest of the three. In the western region of the plateau of sheet 57 I/4, extensive boulders of whitish saccharoidal quartzite rest upon the plateau quartzite, weathered along joints in such a manner as to look like curious aggregates of cuboidal blocks.

The Kundair beds of limestones and calcareous shaly flags appear in the northern and eastern portions of sheet 57 I/8 and in sheet 57 I/7. The colour of the flags changes here from grey-buff to purple, and the change of colour along the Kundu Eru is clearly visible near Harivaram (57 I/8—78° 22′ 0″:15° 10′ 10″). There is a perfect transition in the field between grey-buff calcareous flags and buff or purple argillaceous flags.

Cuddapah basin, Kurnool district, Madras.

Systematic geological mapping of the N.W. portion of the Cuddapah basin in sheets 57 I/1, 2 and 5, and 56 L/8 was carried out by Mr. V. Venkatesh. The following is the general succession of the rocks studied in this area:

Kurnools	Kundair	Nandyal shales; Koilkuntla limestones;
	Paniam	Pinnacled quartzite; Plateau quartzite;
	Jammalamadugu	Owk shales; Narji limestones;
	Banganapalle	Standstones and conglomerates.
Upper Cuddapahs		Quartzites;
Lower Cuddapahs		Tadpatri shales; Pulivendla quartzites; Vaimpalli limestone; Gulcheru quartzite.

The western and north-western margins of the area are hilly and mainly made up of Cuddapah rocks, whereas the central area is a plain country underlain by limestones and shales of the Kurnool series. The general dip of the Cuddapahs is in an easterly direction while the Kurnools are invariably horizontal where undisturbed.

Cuddapahs.—The oldest of the Cuddapah rocks, the Gulcherus, comprising conglomerate, grit and quartzite, are seen to rise in a scarp above the low lying gneissic country to the west. Their dip is usually to the east and between 5° and 15°. The pebbles in the conglomerate which are mostly of vein quartz and quartzite are well rounded, and vary in size from a couple of inches to eighteen inches across. The quartzites and grits exhibit profuse current-bedding. They are found to thin out when followed towards Puduru (78° 8′ 30″:15° 51′) and Satanikota (78° 12′ 30″: 15° 55′) and at places completely disappear. Very good outcrops of these conglomerates and pebble-beds can be seen on the scarp running parallel to and east of the railway line to Kurnool, in sheets 57 I/1 and 2.

Overlying the Gulcherus conformably are the Vaimpallis, at the base of which a small thickness of purple shales and intercalated quartzite is commonly noticed. These are overlain by beds of cherty limestone and cherty quartzite. A belt of Vaimpalli rocks outcrops from near Narunuru (78° 5′ : 15° 42′ 40″) to Puduru striking roughly N.N.E.--S.S.W. and dipping at about 5°-10° to the E.S.E. or east. Sills of trap rock were noticed in the Vaimpallis extending from near Chinnavanni Konda to the north of Rudravaram (78° 5′ 20″ : 15° 45′ 30″) and near Punduru and Alluru (78° 12′ 30″ : 15° 52′).

Quartzites and chert beds with some conglomerates form the Pulivendlas whose junction with the Vaimpallis is considered conformable. Cherty conglomerates and quartzites form the lower beds while the upper beds are ripple-marked quartzites. Good exposures of the Pulivendlas are seen in sheet 56 L/8 east of Sangameswarm (78° 20′ : 16° 1′ 30″).

The Tadpatri shales overlying the Pulivendlas are mottled, greenish grey, olive or drab in colour and weather into thin chips. They occupy the floor of the north-south Durgam valley in sheet 56 L/8. The junction between the Pulivendlas and Tadpatris is marked by a trap sill for some distance in this valley. Another prominent sill was also observed higher up in the Tadpatris.

Overlying the Tadpatris unconformably is a conglomerate followed by fine to medium grained quartzites, light pink or brownish red in colour and showing abundant ripple-marks.

Kurnools.—The Cuddapah rocks are often unconformably overlain by the Banganapallis which are chiefly horizontally disposed sandstones and conglomerates with small pebbles of well rounded chert and jasper of green, grey and red colours. Since the sandstone and pebble-beds at places resemble closely those of the Pulivendlas, there is some doubt regarding the age of the rocks around Gadidemandugu and other places. The Banganapallis have also thinned out in some places, and south of Kurnool they overlap on to the crystallines.

Jammalamadugu limestones and shales overlie the Banganapallis quite conformably, and at the junction a peculiar and characteristic brecciated band of limestone with small pebbles of quartzite and jasper is found at many places. The lower limestones of the Jammalamadugus are light ash-grey, blue or fawn in colour and splintery, while the limestones further up are flaggy, and contain pyrite crystals. These are exposed in a belt parallel to the Vaimpallis in the S.E. portion of sheet 57 I/1. Light brown, buff or purple coloured Owk shales follow these flags and are seen in a continuous outcrop from Diguvapadu (78° 11′:15° 46′ 20″) to Moravakonda (78° 15′ 45″:16° 0′ 40″). A big patch of the Jammalamadugu limestone overlapping and resting directly on the crystallines is seen west of Kurnool.

Plateau and pinnacled quartzites which are fine to medium grained quartzites and grits belonging to the Paniams overlie the Jammalamadugus. They are best exposed around Varakuru (78° 10′ 40″:15° 41′ 15″) (where they show ripple marks), and south of Puricherla (78° 8′ 15″:15° 43′ 20″) and Diguvapedu (78° 11′:15° 46′ 20″). The lower plateau beds and the upper pinnacled quartzites are distinguished by their bedding, jointing and weathering. The Paniams are seen to thin out northwards and completely disappear near Damagatla (78° 13′ 30″:15° 48′ 30″) where the Jammalamadugus are directly overlain by the Kundairs.

The Kundairs overlie the Paniams or the Jammalamadugus quite conformably. The lower division of the Kundairs comprises dark to light grey flaggy limestones with embedded pyrite crystals, whereas the upper division is more argillaceous and made up of purple calcareous Nandyal shales. Extensive areas of plains in sheet 57 I/5 are covered by the Kundairs as also are some areas in sheet 57 I/2.

Structure.—There is little in the area that is structurally interesting. Along the southern boundary of the Loddipalle Reserved Forest (sheet 57 I/2) faulting with downthrow to the north was observed. The other and more important fault striking N.W.–S.E. in sheet 57 I/1 has been named the Siddireddipalle (78° 5′:15° 47′) fault. This fault has shifted westward the Vaimpalli beds and associated trap on the downthrow side (which is north-east).

North of Musalimadugu the east-west edge of the Cuddapah quartzites exhibits a dip of about 40° to the south (the original dip further north being at small angles to the east) probably on account of a fold with an east-west axis. At a couple of places immediately south of these steeply dipping quartzites, Kundair limestone is also seen showing a similar dip, though further south they are perfectly horizontal. This is suggestive of post-Kurnool monoclinal folding, but the paucity of good outcrops and presence of thick soil cover make observations difficult.

Ramnad district, Madras.

Mr. V. Gopal examined and mapped in detail an area of about 270 square miles at the south-western corner of Aruppukkottai *taluk* and the south-eastern corner of the adjoining Sattur *taluk* in sheets 58 K/3 and 58 G/15.

The portions of the Ramnad district examined form a level tract of thick black cotton soil studded with occasional knolls and hillocks of granitic rocks.

The general geological formations met with in the area comprise the following rock-types :—

Recent and sub-recent.	Recent and sub-recent soils, alluvium of the Vaippa-river, laterites, tufa and *kankar*.
Pre-Cambrian metamorphic group.	6. Younger granitic injections, pegmatites, etc.
	5. Charnockites and associated hybrid types.
	4. Composite gneiss-pink and grey granitic gneiss, mica and hornblende-gneiss, garnetiferous types.–hornblende-schists, biotite-schists, etc.
	3. Crystalline limestones, calciphyres and calc-granulites.
	2. Quartzites.
	1. Basic metamorphic rocks — amphibolites, epidiorites pyroxene-schists, etc.

1. *Basic metamorphic rocks.*—Basic metamorphic rocks such as biotite-schists, amphibolites, epidiorites and pyroxene-schists are found in small patches amidst the composite gneisses.

2. *Quartzites.*—A few thin parallel beds of quartzite occur traversing the ridges to the east of Reddiyapatti (9° 25′ 15″ : 78° 12′ 30″). The quartzites are found intercalated with biotite-gneisses. They are coarse grained and granular and carry only thin films of weathered iron-oxide.

3. *Crystalline limestones, calciphyres and calc-granulites.*—Bands of crystalline limestone are seen (1) to the south and south-west of Pandalkudi (9° 23′ 45″ : 78° 6′ 20″), (2) to the north and east of Palavanattam village on the Virudhunagar-Aruppukkottai road and (3) to the north and west of Vachchakkarapatti (9° 28′ 0″ : 77° 56′ 0″). Usually the limestone contains coarse, spathose crystals of calcite with medium-grained green coccolite. But finer grained saccharoidal limestone and marble is also met with. The limestone varies in composition from band to band depending upon the amount of ferromagnesian minerals present. Carbonaceous limestones and marbles occur near Pandalkudi.

Gneissic rocks containing small crystals of calcite with a large amount of ferromagnesian minerals are of common occurrence in the neighbourhood of the crystalline limestones.

4. *The composite gneisses.*—The composite gneisses which form the country rock include finely bedded and banded rocks such as mica and hornblende-gneiss, garnetiferous gneisses and calc-gneiss, intercalated with biotite-schists, hornblende-schists. amphibolites, epidiorites, crystalline limestones, quartzites and pyroxene and calc-granulites.

In the east near Reddiyapatti and Pandalkudi the rocks have a general N.W.-S.E. trend. Near Malaipatti (9° 28′ 45″. 78° 0′ 35″) the strike is roughly east to west while still further west, near Sattur (9° 21′ 30″ : 77° 55′ 30″), they have a N.E.-S.W. trend. The gneisses have steep dips eastward or westward.

5. *Charnockites.*—Admixtures of hybrid charnockites and dark norites are seen occurring as thick bands amidst the composite gneisses. Large exposures of charnockite are seen near Kallurani (9° 28′ 0″ : 78° 9′ 30″), Chettikurichchi (9° 27′ 0″ : 78° 5′ 30″) and Malaipatti (9° 28′ 45″ : 78° 0′ 35″). The rocks show banding and foliation on the weathered surface.

6. *Recent and sub-recent soils, etc.*—Most of the area examined is covered with thick black cotton soil rich in lime. Kankar is very commonly found as concretions and pebbles in the black soil. Laterites and red lateritic soil are seen in isolated patches especially in the high grounds and near quartzite bands.

On either side of the Vaippar river a narrow strip of fine alluvium occurs for a width of two to three furlongs near Nenmeni (9° 19′ 0″ : 78° 0′ 15″).

Tinnevelly district, Madras.

Mr. S. Narayanaswami carried out systematic geological survey in the Tinnevelly district, Madras Province, in continuation of the work carried out by him during the previous five field-seasons. The area surveyed and mapped is about 1,200 square miles, comprising the entire portion of the Srivaikuntam and Kovilpatti *taluks* in parts of sheets 58 L/1, 5 and 2, 58 H/13, 14 and 16, 58 K/3, 4 and 8.

In the course of field work, Messrs. V. Gopal and J. Narayanamurthy, newly appointed Assistant Geologists, joined him and assisted in the mapping.

The area examined and mapped forms a monotonous level tract of thick black cotton soils for the major portion. Red soils occur at the southern end of the area and a narrow belt of red "teri" dunes and younger coastal sands stretch along the coastal region. The general geological formations met with in the area comprise the following rock-types :—

Recent and sub-recent.	9. Recent and sub-recent soils, younger coastal sands, alluvium of the Tambraparni and Vaippar, tufa and *kankar*, laterite, etc.
	8. Older red "teri" sands and dunes.
	7. Recent and sub-recent sandstones, shell limestones etc.
	Unconformity
Pre-Cambrian metamorphic group.	6. Younger granitic injections, pegmatites, etc.
	5. Charnockites and associated hybrid types.
	4. Composite gneisses—granitic and mica-gneisses, garnetiferous gneisses, pink granites, schists, etc.
	3. Crystalline limestones, calciphyres and calc-granulites.
	2. Quartzites.
	1. Basic metamorphic rocks—amphibolites, epidiorites pyroxene-schists, etc.

1. *Basic metamorphic rocks.*—Rocks of basic metamorphic composition are chiefly amphibolites, epidiorites, hornblende-schists, noritic schists and green pyroxene-granulites and schists, and these occur commonly as thin bands and intercalations amidst the pink and grey granitic gneisses and composite types. Dark epidiorites and hornblende-granulites also occur as intercalations amidst the quartzite beds.

2. *Quartzites.*—Beds of coarse granular quartzites similar to those noticed in the other parts of the district traverse the gneisses and form prominent ridges in the area. In the region of the Vallanadu hills, a set of three or four groups of parallel beds were mapped making an acute southerly bend; these are the continuations of the quartzites mapped previously in the adjoining portion of the Tinnevelly *taluk* to the west. Another important group of quartzite beds form the ridges adjoining Ottappidaram (80° 54′ 45″ : 78° 1′ 25″), and these are continued northward making a semi-circular westerly curve in the region of the Kurumalai hills (·831, ·786, ·754 feet) and the ridges (·649, BM. 546, etc.), adjoining Kovilpatti town. A small group of beds extend between Maniyachchi (8° 51′ 45″ : 77° 53′ 45″) and Kadambur (8° 59′ 45″ : 77° 51′ 45″), and a set of irregular beds make up the hillocks adjoining Pudukkottai (8° 44′ 30″ : 78° 3′ 5″).

3. *Crystalline limestones, calciphyres and calc-granulites.*—Thin intercalations of calc-granulites, impure crystalline limestones and calciphyres are seen at many places within the composite gneisses, at places admixed and hydridised with the

granitic materials. One fairly extensive band of white crystalline limestone mixed with coccolitic material and calc-granulites occurs in a N.W.-S.E. line cropping out at Deyvachchilaipuram (8° 44′ 15″ : 77° 55′ 15″), Singattakurichchi (8° 47′ 15″ : 77° 53′ 0″), Kalappaipatti (8° 52′ 45″ : 77° 49′ 0″) and northward towards Kayattar (8° 57′ 0″ : 77° 46′ 30″). To the north-west of Kayattar a small band of coarse calcitic limestone carrying a lesser admixture of calc-silicates occurs at Nagalapuram (8° 59′ 50″ : 77° 44′ 0″). Apart from these, smaller occurrences of crystalline limestones are noticed at Tattapparai railway station (8° 49′ 40″ : 78° 1′ 30″), south of Eppodumvenran (9° 1′ 10″ : 78° 3′ 0″), around Pasuvandanai (8° 59′ 50″ : 77° 58′ 0″), adjoining Ettaiyapuram (9° 8′ 45″ : 77° 59′ 45″), and in the region around Pudur (9° 17′ 30″ : 78° 8′ 15″). Many of these have been digested by the granitic injections and occur now as small caught-up fragments.

4. *Composite gneisses.*—The country rock in the greater portion of the area is a finely foliated composite type of gneiss, showing varying admixtures of alternate bands of pink and grey granitic gneisses, with frequent intercalations of amphibolites epidiorites, hornblende-schists and green pyroxene-granulites, and occasionally beds of quartzites and calc-rocks. The rocks are profusely injected with granite and pegmatite in *lit-par-lit* fashion. The general trend of the gneisses varies from N.W.-S.E and N.N.W.-S.S.E. at the southern portion to nearly N.-S. and N.N.E.-S.S.W. at the central part and thence to N.N.W.-S.S.E. and N.W.-S.E. at the northern end. There is much disturbance and a semi-circular easterly folding of the rocks in the region of Kurumalai hills and Kovilpatti town (9° 10′ 30″ : 77° 52′ 15″). The dip of the rocks is generally to the S.W. or W.S.W., but there are also frequent cases of easterly dip.

5. *Charnockites and hybrid types.*—Charnockites are sparse and sporadic and are noticed as small local bands intimately mixed up with the gneisses and much hydridised. Foliated and banded hybrid gneissic charnockites are seen adjoining Kayattar and Vallanadu (8° 43′ 0″ : 77° 51′ 10″). Typically massive charnockitic rock forms the Kasavankunru and Malaippatti hillocks near Ettaiyapuram. Admixtures of schistose noritic types are very common amidst the pink granite bands and composite gneisses.

6. *Younger granitic injections.*—The composite gneisses are everywhere profusely injected with granitic materials which occur generally as bands along the bedding planes of the other

rocks. The granite and pegmatite are coarse grained, pink and white, and carry pink or white felspar, quartz and cracked books of black mica; green pyroxene, hornblende and large crystals of garnet are seen where they are associated with schistose bands and garnetiferous gneisses.

7. *Recent and sub-recent deposits.*—The stretch of coastal tract for a width of three to six miles is underlain by sandstones, shell limstones and loosely indurated shell-bearing sandy rock of recent and sub-recent age. The beds are generally coarse, loose-textured and friable, occurring completely obscured by the overlying sandy accumulations and are just in the process of compaction.

8. *Red "teri" sands.*—A narrow belt of red "teri" sands and ridges extends continuously along the coastal region within two to three miles off the shore. These indicate the probable former extent of the coast line. The reddish staining of the sands appears to be due to the weathering of the dark ilmenite grains contained in them.

9. *Recent and sub-recent soils, etc.*—The major portion of the area is underlain by thick black cotton soils which range to depths of three to fifteen feet. Red sandy lateritic soils occur generally around the quartzite ridges as detached patches in the black-soil country. Laterite is seen at places at the foot of the quartzite ridges. The black soil appears to be rich in lime, and beds of concretionary *kankar* occur commonly along stream-courses draining the area. There is thick alluvium for two to three miles along the Tambraparni and for half to one mile along the Vaippar river. Between the ridges of red "teri" sands and the shore there occur accumulations of white coastal sands of recent age.

Trichinopoly district, Madras.

Systematic mapping of a portion of the Karur *taluk*, Trichinopoly district, on sheet 58 J/1 has been carried out by Mr. A. P. Subramaniam. The following general sequence of rocks has been established after detailed examination of the area :—

Younger	Pegmatites-quarz veins,
	(?) Hornblende-granite,
	Charnockite,
	Granitic gneiss with inclusions of older composite gneiss and hornblende-gneiss, and variations of the same.

Older	(?) Hornblende-granulite,
	Composite gneiss,
	Hornblende-gneiss,
	Calc gneiss—calc, silicate rock,
	Limestone,
	Biotite-quartz-schist,
	Magnetite-quartz-schist,

There is no uniformity in the strike or dip of the entire series of rocks taken as a whole. In the western portion of the sheet occupied by the older gneisses, the rocks trends N.W.-S.E., veering to E.N.E.-W.S.W. towards the east, while the general strike changes from N.E.-S.W. to E.W., while proceeding west from the eastern portion of the area mapped.

III. MINERAL INVESTIGATIONS.

Apatite

Almora district, United Provinces.

Mr. G. Kohli made a rapid examination of the 12-mile long road-section between Bhowali and Garampani *en route* to Almora, to locate an alleged apatite deposit reported by the Deputy Director of Agriculture, United Provinces.

It appears, however, that this enquiry was referred to this Department by the United Provinces Government as the result of inaccurate analyses and consequent mis-identification.

Asbestos

Ajmer-Merwara.

Mr. B. N. Sinha reports occurrence of asbestos of poor quality near Gudas (74° 46′:26° 29′ 15″) in actinolite-schists and serpentine rocks. The veins run N.N.E.-S.S.W. and are not thicker than 1½ inches.

Ceded districts, Madras.

Mr. V. Venkatesh found stray pieces of asbestos in the well diggings north of Bhiravapuram (15° 41′: 78° 2′). According to him the occurrence is not likely to be of any economic importance.

Barytes

Kurnool district, Madras.

Mr. V. Venkatesh noticed fragments of barytes strewn in a cultivated field N.E. of Yaparlapadu (15° 39′: 78° 0′). Several small pits for barytes were noticed on the border of the Reserve forest north-west of Gadidemadugu. The mineral occurs as segregations in chests and is of good quality; but the reserves are limited.

Bauxite

Balaghat district, Central Provinces.

Mr. M. K. Roy Chowdhury examined the bauxite deposits at the following localities in the Topla and neighbouring highland, Balaghat district.

Touri Dadar (22° 10′:80° 49′).—About 100,000 tons of good quality bauxite may be obtained from this plateau. The best enrichment occurs in the scarps at the northern and western rims of the plateau. *Deoli Dadar* (22° 19′:80° 49′)—At the headquarters of the Kashmiri *nala* and particularly on the western side of the path leading from Dudhania (22° 09′:80° 51′) to

Jholar (22° 07′ : 80° 49′), a fairly good concentration of bauxite occurs at the margin of the plateau. The total reserves are likely to exceed 25,000 tons of bauxite. *Kauwajhar Dadar* (22° 08′ : 80° 47′)—A segregation of grey bauxite occurs at the head of the nala north-east of the plateau. This is the only appreciable deposit of bauxite in the laterite cappings of the long ridge that runs from Sukhari (22° 07′ : 80° 55′) to Garaghat (22° 08′ : 80° 46′). About 10,000 tons of ore has been estimated from this area. *Garhi Dudar* (22° 11′ : 80° 53′)—Over 40,000 tons of bauxite may be expected on the spur to the north-eastern side of the plateau. *Supkhar* (22° 12′ : 80° 56′)—Near the middle of the ridge north of Supkhar occasional boulders of good quality bauxite occur. Only a few thousand tons of the ore are available. *Larwa* (22° 08′ : 80° 57′)—The ridge north of Larwa shows good development of bauxite, especially on the western side that overlooks the valley of the Chakarda stream and at the head of the *nala* that cuts a deep notch in the north-east corner of the plateau. The deposits are likely to yield up to 50,000 tons of bauxite. *Chatarpur* (22° 04′ : 80° 00′)—At least 40,000 tons of good bauxite may be expected from the extreme southern side of the plateau.

Maihar State, Vindhya Pradesh.

Mr. G. V. Rao reports small segregations of pisolitic bauxite near a group of hillocks one and half miles west of Amgar village (24° 08′ : 80° 50′). The occurrences are of only academic interest.

Beryl

Ajmer-Merwara

Mr. B. N. Sinha reports the occurrence of large beryl crystals from a quarry to the east of Kasarpura (74° 52′ 45″ : 26° 15′).

Chromite

Salem district, Madras.

Mr. A. P. Subramaniam carried out a detailed examination of the chromite-corundum belt of Namakkal *taluk*, Salem district. Chromite was discovered in this area in 1944, in close association with the corundum-bearing anorthite-gneisses. The entire belt of chromite-bearing rocks has been re-mapped on a large scale with a view to obtaining precise data on the mode of occurrence and distribution of the chromite ore bodies and reserves of ore, The main types of rocks noticed in the area are:—

3. Granites, pegmatites and associated quartz-veins.
2. Chromite-amphibolites, pyroxenites, pyroxene-garnet-rock, hornblende-garnet-rock and their variants.
1. Anorthite-gneiss, hornblende-gneiss, biotite-gneiss, hornblende-garnet-gneiss, calc-gneiss and crystalline limestone.

The anorthite-gneisses and associated rocks form an arcuate belt extending from Pattalur (11° 66′ 30″ : 77° 3′) in the west to Kottakkalpalaiyam (11° 16′ 30″ : 78° 1′) and beyond in the east with a maximum width of about a mile and a half. The general strike of the rocks follows the run of the outcrop veering gently from N.W.-S.E. on the western end to N.N.E.-W.S.W. towards the eastern end with southerly dips of 60°-70°.

Chrome-ore occurs in amphibolites which form sill-like bodies along the foliation-planes of the anorthite-gneisses. The bands of chromiferous amphibolites vary in thickness from a few inches up to as much as ten feet. Many of these ore bodies have been exposed along the junction of the anorthite rock and the amphibolitic sills. The reserves of chrome-ore over the entire belt are likely to be of the order of one quarter million tons for the first twenty feet depth.

China clay

China clay, Ganjam district, Orissa.

Mr. G. H. S. V. Prasada Rao reports a small exposure of China clay about thirty feet in length, three feet wide and one foot in thickness, in the bed of a *nala*, one and a half furlongs south-east of Bramarapur (19° 05′ : 84° 41′). The clay has resulted from the alteration of granulitic rocks. The material is locally used for white-washing after mixing it with lime. Mr. Y. G. K. Murty reports the occurrence of a very small deposit of white to yellowish clay in association with river alluvium on the left bank of the Haribhang river opposite Adaba (19° 29′ : 84° 11′).

China clay, Sambalpur district, Orissa.

Mr. Kedar Narain reports the occurrence of China clay resulting from the weathering of gneissic rocks, about one furlong north of Matapali (21° 24′ : 83° 38′). Mr. A. M. N. Ghosh and Mr. Kedar Narain examined a China clay quarry about half a mile north-east of Chuhukitikra (21° 39′ : 84° 09′). The clay stretches E.S.E.-W.N.W. along a zone of kaolinisation brought about presumably by hydrothermal action and is underlain by highly dipping decomposed chloritic schists and overlain by decomposed gneissic rocks. Large amounts of gritty materials have spoilt the clay which can, however, be improved by washing. The quality is likely to improve at depth.

Mr. A. M. N. Ghosh and Mr. Kedar Narain examined a deposit of fire-clay about half a mile N.N.E. of Khinda (21° 43′ : 83° 58′) in the Sambalpur district. The fire-clay occurs at the base of Barakar sandstones near their junction with the underlying Talchirs. The deposit extends for about a mile further north with slight interruptions. At one place the clay dips at 25° towards north-west. The clay is hard, compact, creamy white when fresh and appears to be of good quality. Occasionally it is stained with ferruginous material which imparts to it a chocolate colour. The deposit is worked by Mr. C. P. Misra of Sambalpur. The clay is transported by bullock carts to Lapanga railway station, which is five miles away.

China clay, Datia State, Vindhya Pradesh.

Mr. M. K. Roy Chowdhury records the occurrence of white clay on the southern flank of the hillock west of Diroli (26° 12′ : 78° 42′). The clay is of low grade but the size of the deposit may warrant exploitation.

Fire-clay

Fire-clay, Amraoti district, Central Provinces.

Mr. S. M. Mathur records beds of white clay varying in thickness from five to ten feet, interbedded with the Gondwana sandstones near Belkher (21° 22′ : 77° 31′). There are three such beds extending for about 500 yards. Several small pockets of clay of inferior quality are also present, west of Pandhri (21° 22′ : 77° 33′). On the hills between Khakasima Pir and Bairam Ghat (21° 22′ : 77° 37′) there are several shallow pits of clay in sandstones. The largest pits are to the north of Bairam Temple and they sometimes measure fifty feet in length and fifty feet in width. The clay is locally used for whitewashing village huts.

Fire clay, Chanda district, Central Provinces.

Mr. S. M. Mathur records the occurrence of several pits of white clay in the Reserved Forest area on both sides of the Chanda-Allapalli Road, about a mile east of Kothari (19° 47′ : 79° 59′) The clay occurs in patches of varying sizes ; some of them measure about 100,000, 40,000, 20,000 and 10,000 square yards in extent.

Mr. Mathur also noted the following occurrences of fire-clay in the Kamthi sandstones of the Wardha Valley coalfield:

(1) near Isapur (19 53′ : 79° 19′) clay is found in an area measuring about 400 yards in length and 75 yards in width, (2) about a mile north of Ballarshah (19° 51′ : 79° 21′) there are several small pits where clay is being quarried, (3) two and a half miles west of Junana (19° 55′ . 79° 23′) there is a patch of clay measuring about 100 yards in length and 20 yards in width in the forest, (4) a small patch on the western outskirts of Kothari (19° 47′ : 79° 29′), (5) an outcrop of white clay near Katali (19° 46′ : 79° 29′) on the bank of the Wardha river and (6) an exposure in a cutting near mile post 765 on the narrow gauge of the B. N. Railway.

Fire-clay, Nagpur district, Central Provinces.

Mr. P. K. Chatterjee records an occurrence of white intertrappean(?) clay near Khapri (21° 15′ : 78° 49′) on the Katol-Nagpur road. The material is locally used for whitewashing. The clay is exposed at surface and continues a few feet below the ground level. Near Chorkheri (21° 27′ : 78° 40′), Shemda (21° 27′ : 78° 42′) and about a mile south-west of Khairi (21° 09′ : 78° 49′), soft white clay occurring below red and yellow argillaceous sandstones is worked for the manufacture of pottery.

Fire-clay, Maihar State, Vindhya Pradesh.

Mr. G. V. Rao reports a number of occurrences of clay, along the foot of the Kaimur Range, resulting from alteration of the Lower Vindhyan shales. Usually the clay is soft and white in colour. The clay is used for whitewashing village huts. A quarry near Badampur (29° 10′ : 80° 43′) is about 75 feet deep.

Lithomarge

Lithomarge, Tripura State.

At the request of Mr. A. B. Chatterjee, Dewan, Tripura State, Dr. A. K. Dey and Mr. V. H. Boileau visited Paschim Champamura (23° 50′ : 91° 20′) about two and half miles east of Agartala, to examine an occurrence of clay exposed in a trial pit.

The clay exposed below a capping of soil in the shallow pit is white, mottled with iron stains. The material appears to be a weathering product of shales, being further altered by ferruginous percolation, probably from sands and laterite on the hill top. Tests made on samples of this clay gave the following results :—

> Colour before firing—white or cream; after firing—cream; plasticity—medium; does not fuse at 1,380° C.; shrinkage (linear), 10 per cent.

The material appears to be suitable for the manufacture of pottery; but sources of materials other than the clay, for different types of ware, have still to be found, and the proportionate quantities of these determined by research on bulk samples. Further prospecting seems necessary to prove the extent of the deposit so as to be sure of the supply of clay in case establishment of a pottery works is contemplated.

White clay

White clay, Guntur district, Madras.

Mr. S. N. Sen records occurrence of white clay about two miles south-west of Vinukonda, south of the railway line, over half a square mile in area. The thickness of the deposits varies from six inches to one and a half feet.

(See also pages 85-91.)

Coal

Sibsagar district, Assam.

Mr. T. Banerjee examined the occurrence of coal at Koilapahar (25° 59′ 50″ : 93° 33′ 40″) on the bed of the Koilajan river. He found indications of earlier attempts to prove the field. The coal seam, three to five and half feet in thickness, occurs interbedded with the Cherra sandstone overlying the Sylhet trap and Archæan gneisses exposed in the bed of the Koilajan. The Cherra sandstone is overlain by nummulitiferous Sylhet limestone. The seam dips 5-15° E:N.E. The coal is hard columnar and jointed on the surface, and contains abundant fossil resin marks. A sample on analysis shows :—

	Per cent.
Moisture	8·82
Volatile matter (less moisture) . . .	50·78
Fixed carbon (by difference)	32·16
Ash	8·24

The coal is non-caking. A sample showed 2·09 per cent. sulphur. Owing to the limited area of the field, workable reserves are of the order of 624,000 tons. Because of thick overburden, the seam lying close to the river level must be worked by inclines which would be liable to flooding, making exploitation expensive on account of roof-support and pumping required.

Mandi State, Himachal Pradesh.

Mr. G. Kohli examined the abandoned coal mines near Mansai (31° 34′ : 76° 51′ 30″). The coal which is of Tertiary age was locally reported to be rich in volatile constituents. The carbonaceous horizon is not extensive, being traceable for a distance of about 100 yards only. The beds strike N. 15° E.-S. 15° W., and have a westward dip at 30°. It would appear from the existing traces of mining operations that an attempt was made to exploit this coal but was subsequently abandoned.

There is another disused mine (31° 33′ 50″:76° 51′) about half a mile to the south of the one previously mentioned. The seam here is about three feet thick and strikes north-east, the dip being westward at 30°. It can be traced for a distance of about 50 yards to the south. This outcrop appears to be in continuation of the Mansai outcrop.

The analysis of an average sample from Mansai, carried out in the Geological Survey of India Laboratory, is given below:—

	Per cent.
Moisture	1·24
Volatile matter (less moisture)	12·06
Fixed carbon (by difference)	31·52
Ash	55·18

The conclusion arrived at from an examination of these outcrops is that the coal in this area is not likely to be economic importance. However, Dr. Sahni, Superintending Geologist, in charge of the Northern Circle, recommends detailed mapping without which a conclusive opinion cannot be expressed.

Suket State, Himachal Pradesh.

Dr. M. R. Sahni carried out a survey of the reported coal occurrences at Dehar (31° 25′ 35″ : 76° 48′ 40″), sheet 53 A/15 (Himachal Pradesh), at the request of the Regional Commissioner, East Punjab States. At the same time he examined the coal occurrence at Kapahi, near Sundernagar, Suket State.

The coal outcrop near Dehar (31° 25′ 35″ : 76° 48′ 40″), sheet 53 A/15, occurs in and near the steep right bank of the Sutlej river about 300 yards upstream of the suspension bridge. The carbonaceous horizon is interbedded with limestones which dip almost vertically and strike N. 10° W.-S. 10° E. The limestones are overlain by sub-recent boulder beds. Two carbonaceous seams about six feet and three feet in thickness were noticed and were traced for a distance of about a 100 yards to the north, where they crop out again on the other bank of a small stream. In Dr. Sahni's opinion, this coal horizon is not of Tertiary age but occurs within the Krols. Detailed mapping will probably show that the Krols here are thrust over the Tertiaries. It is obvious from the foregoing, especially the vertical dip of rocks and the limited extent of the carbonaceous horizon that the coal is not likely to be of economic importance. No useful purpose would therefore be served by carrying out a detailed survey of this region.

The average analysis of coal samples collected from Dehar and carried out in the laboratory of the Geological Survey of India, is as follows:—

	Per cent
Moisture	2·53
Volatile matter (less moisture)	12·79
Fixed carbon (by difference)	18·58
Ash	66·10

Coal crops out in small discontinuous patches over a very small area near Kapahi (31 32′ 15″ : 76° 51′ 20″), sheet 53 A/14. Though the carbonaceous horizon occurs within strata of Tertiary age composed mostly of sandstones, the rocks are much disturbed and dip at high angles, about 55° E.S.E. Analyses carried out in the Geological Survey of India laboratory show that the coal is of better quality than that at Dehar. It is, however, not likely to be economically workable on account of the disturbed nature of the country and limited extent of the outcrop, so far as our present knowledge goes.

The analysis of an average sample from Kapahi, carried out in the Geological Survey of India laboratory, is as follows:—

	Per cent.
Moisture	1·34
Volatile matter (less moisture)	24·86
Fixed carbon (by difference)	65·64
Ash	8·16

The coal horizon near Arthi (31° 31′ 45″ : 76° 51′ 45″), sheet 53 A/14, examined by Mr. G. Kohli, is seen to crop out in the right bank of a small stream, about three furlongs south-east of Arthi and is of Tertiary age. The coal, which is sheared, is stained in dull greyish yellow and rusty colours on the surface. It is not traceable across the stream but occurs for a distance of about 150 yards southwards. While no definite opinion can be expressed in view of the tectonic adjustments that have taken place here, the two outcrops near Arthi probably belong to an identical seam, in which case the strike would be almost north-south. However, this can only be determined by detailed mapping. Preliminary examination indicates that the workable coal horizon is not likely to be of large extent.

The analysis of an average sample from Arthi, carried out in the Geological Survey of India laboratory, gives the following figures:—

	Per cent.
Moisture	1·50
Volatile matter (less moisture)	10·16
Fixed carbon (by difference)	28·54
Ash	59·80

Mr. F. Ahmad carried out a survey of the coal area around Kota (24° 6′ : 82° 45′), Rihand Sheet No. 3, with a view to locating sites for bore-holes. He reports that a pebble bed occurs about 50 feet above the coal horizon near the old incline at Kota and that a similar pebble bed has been located elsewhere in the area at the same horizon. He has suggested certain sites for boring.

Copper-ore

Guntur district, Madras.

Messrs. S. N. Sen and N. V. Chandrasekariah visited the old copper workings at Dhukonda. A number of pits and trenches believed to be put about 100 years back are noted on the top and on the north-eastern and southern spurs of the Dhukonda and also on the ·469 hillock, lying to the south of the Dhukonda. Quartzites with Cu-stains are found in the area. Here the dip of the rocks varies from 45° to 60° N.E. to E.S.E. Apart from Cu-stains on quartzites and a few small pieces of malachite, no vein or large pieces of copper-ore are found.

Diamond

Cuddapah basin, Madras.

Ancient workings and pits for diamonds were noted by Mr. V. Venkatesh, in the course of his systematic mapping of the Cuddapah basin at Kalava (78° 12′:15° 37′ 15″), Kannamadakala (78° 11′ 15″:15° 42′ 15″) Chautukur, Puduru, Devamada (78° 7′:15° 49′ 30″) and Marugutti (78° 23′: 6° 3′ 30″).

Gold

Salem district, Madras.

Mr. N. K. N. Aiyengar reports the occurrence of auriferous magnetite sand in a stream south of Singiliyankombai (11° 32′ : 78° 25′) and on the western slopes of the hill east of Isvaramurthipalaiyam (11° 34′:78° 24′) in Salem district, Madras.

Mr. A. S. Ramiengar reports traces of gold in the sands of the small *nalas* emerging from the west of the Paittur Reserved Forest Hills. Panning for gold after heavy showers is customary amongst a section of the local people of the area.

Graphite

Athmallik State, Orissa.

Mr. S. C. Chakravarty has examined small and uneconomic deposits of graphite distributed over a large area in the schists of the khondalite series in the Athmallik State. Graphite also occurs in association with garnetiferous gneisses and calc-silicate rocks and exposures of graphitic-schists are often found in *nala* sections. The graphite-bearing rocks are generally much weathered and decomposed. From the data obtained from geophysical prospecting it appears that the concentration of graphite is limited to a number of horizons and that there are deposits of varying richness more or less along a 'graphite line' or a zone within the metamorphosed sediments.

There is a quarry at Dandatapa (20° 48′ : 84° 36′) where some high grade graphite occurs, as the following analysis of a picked sample shows :—

	Per cent.
Moisture	*nil*
Volatile matter (less moisture)	0·80
Fixed carbon (by difference)	96·74
Ash	2·46
Colour of ash	Salmon pink.

At the above quarry graphite occurs in a vein 5 feet wide, along a contact of granite and pegmatite intrusive into the rocks of the khondalite series. The quarry has a length of nearly 105 feet in a N.-S. direction and is 45 feet wide. It has reached a depth of 120 feet below the ground level.

Gypsum

Coimbatore district, Madras.

Mr. V. Subramanyam reports the occurrence of nodules of gypsum in some of the black soil tracts in the southern portion of the Palladam Firka. They are : (i) one mile south of Venkatapuram (10° 57′ 10″ : 77° 15′ 35″), sheet 58 F/15; (ii) half a mile north-east of Puliampatti; (iii) near about the pond west of Mallekavundanpalaiyam (10° 56′ 35″ : 77° 11′ 45″) sheet 58 F/1; and (iv) half a mile north of Kradibavi and west of a big tank. Of these occurrences, the first one is fairly rich in gypsum. The mineral has been noticed in moist brownish clay underlying the black soil. This "kilar" underlying the black soil is not met with in all the places. From a study of three prospecting pits put down in the Venkatapuram area, an estimate of about 20,000 tons of gypsum has been made in this locality within a depth of ten feet from the surface. This estimate is believed to be conservative.

Guntur district, Madras.

Mr. S. N. Sen has noticed small pockets of gypsum in the Archæans about one and half miles west of Madlamuru (15° 48′ : 79° 50′).

Tinnevelly district, Madras.

Mr. S. Narayanaswami reports that the black cotton soil in the Srivaikuntam and Kovilpatti *taluks* of the Tinnevelly district along the stream courses is highly alkaline and the dry stream beds frequently show white salty efflorescences (*reh* salts). This bed of crystalline gypsum associated with kankar is of common occurrence along many of these streams and a few thousand tons of the material will be available.

Ilmenite

Surat district, Bombay.

At the instance of the Director of Industries, Bombay, Dr. B. C. Roy investigated the coastal sand near Bulsar in Surat district, alleged to contain titanium and rare earth minerals, by sinking shallow pits in a two-mile long and one furlong wide strip. The sand is black and represents weathered traps; it occurs in coarse and fine layers, often mixed with gravels and pebbles of traps, sometimes showing false-bedding due to sea or wind action. Ilmenite and magnetite particles occur very rarely as thin films at the surface or within a few feet from the surface, generally associated with fine sand, not more than a few inches in thickness, the percentage of ilmenite being almost negligible. Microscopic examination did not show any rare earth minerals.

Coimbatore district, Madras

Occurrence of thin concentrations of ilmenite and garnet sands has been examined by Mr. S. Narayanaswamy in the sandy coastal areas of Coimbatore district, but the majority of these are too small to be workable. Good patches of the ilmenite sands, however, occur along the coast at the mouths of Vaippar and Kallar rivers, and at Taruvaikkulam (8° 53′ 30″ : 78° 10′ 0″), and these have been already examined and reported in detail by Dr. K. Jacob in 1943.

Iron-ore

Burdwan district, West Bengal.

At the request of the Director of Industries, West Bengal, Mr. D. Gupta carried out an economic survey of the ironstone shale deposits near Barakar and Kulti (23° 44′ : 86° 51′) and estimated the total reserves of the deposits in the area at 8,800 million tons. The percentage of the material fairly rich in iron, recoverable from the extracted ironstone shale was found to vary between five and ten The following are the analyses of two picked specimens:

---	Total Fe	Insol.	Total S	Total P
A	42·94	12·88	0·12	0·81
B	51 94	8·16	0·14	0·35

Mandi State, Himachal Pradesh.

Mr. G. Kohli mapped the Koti Kohar iron-bearing schists at Kohar Khas (32° 5′ : 76° 48′) in sheet 52 D/16. He reports that the iron-ore is mainly magnetite, and occurs as small crystals, disseminated either throughout the mass of quartzite or concentrated into bands, resulting in banded slaty quartzites. The thickness of the bands is never more than a quarter inch and usually does not exceed one-fifth of an inch. The banded portion which used to be worked locally, is about 15 feet thick and its thickness increases rather suddenly towards Sarotha (32° 3′ 30″ : 76° 50′ 15″) near Deot. This is very likely due to isoclinal folding. Iron is sparsely distributed throughout the series. The iron-bearing quartzites have been traced from about a mile north of Baragaran (32° 5′ 30″ : 76° 0′ 30″) to Multhan (32° 3′ : 76° 50′ 45″) where the Koti Kohar area ends, a distance of six miles.

According to Mr. G. Kohli the magnetite-sericite-quartz-schists which contain the iron, are so low in their magnetite content, that there are no prospects of these being exploited as a source of iron as long as the high grade ores in the country are available.

Kurnool district, Madras.

Small lenticular patches and segregations of hematite were noticed by Mr. V. Venkatesh in the cherts of Vaimpallis and Pulivendlas. Ancient workings were observed on ·1328 plateau (sheet 56 L/8) and heaps of slag were noted at Sangameswaram, Kapileswaram (78° 21′ 15″ : 16° 0′ 20″) and Marugutti.

Manipur State.

Mr. T. Banerjee reports occurrence of lateritic gravel in the soil of the marshy low lands around and east of Kakching (93° 59′ : 24° 30′). Locally, as near Phundrei

(94° 03′:24° 33′), the gravel is often concentrated to form iron-ore which is only sufficient to be worked by villagers in times of stress.

Maihar State, Vindhya Pradesh.

Mr. G. V. Rao records the occurrence of iron-ore in the form of limonite as segregated patches in laterite, one and a quarter miles west of Amgar (24° 08′:80° 50′) in the Maihar State. There are several such superficial occurrences of the ore which were previously smelted for iron.

Ganjam district, Orissa.

According to Mr. G. H. S. V. Prasada Rao there are a few pockets of low grade limonite in lateritised khondalites along the banks of a *nala* draining the southern slope of the ridge N.N W. of Limmajinga Parbat near Karadango (19° 09′: 83° 03′). This low grade ore derived from the limonitisation of garnets in khondalite was used in the past for smelting iron.

Mr. Y. G. K. Murty noticed minor occurrences of lateritic iron-ore near Kedrikhel (20° 27′:84° 25′), Rujamgi (20° 27′: 84° 15′) and Luhagudi (19° 28′:84° 22′).

Datia State, Vindhya Pradesh.

Mr. M. K. Roy Chowdhury noticed ancient slag heaps at many places in Datia State, particularly near Gyara (26° 12′: 78° 44′) and Bara Ratangarh (26° 10′: 78° 39′). The ancient smelters probably used for their ore the thicker bands of hematite in the Gwalior shales. Most commonly the ore is a fine wafer-like shale composed of thin flakes of hematite, with still thinner films of clay. Iron-ore veins, occasionally observed in the quartzites of the Gwalior series, are too thin to be of any commercial importance, but may be tapped for local indigenous furnaces.

Kyanite

Ajmer-Merwara.

Mr. B. N. Sinha reports small veins and pockets of kyanite near Gudas (74° 46′:26° 29′ 15″) in association with quartz-schists and quartz-actinolite-schists. The occurrence has no economic significance.

Lead-ore

Chanda district, Central Provinces.

Mr. S. M. Mathur examined a reported occurrence of galena near Potepalli (19° 48′:80° 03′) in the Ghot Range, South Chanda Division. No vein or lode of the mineral could be located, but a few pieces of very small crystals of galena were picked up from the surface near Padmandadda *nala*.

Datia State, Vindhya Pradesh.

Mr. M. K. Roy Chowdhury opened the quartz-galena vein about four miles north-east of Seora (26° 09′ : 78° 47′) in Datia State. Detached lenses of coarsely crystalline galena occur only at the extreme southern side of the lode. Towards the north the vein is poor in ore-content and branches out to barren quartz stringers. Considering the state of mineralisation and the length and width of the vein, Mr. Roy Chowdhury is of the opinion that the deposit is of no economic value.

Associated with the crystalline quartz which occurs in the cavities and vein fillings in the quartzose rock south of Bara Ratangarh (26° 10′ : 79° 39), there are small crystals of galena. Similar occurrences were noticed in a quartz-reef south-east of Chitai (26° 07′ : 78° 39′). The mineral in these occurrences is too sparsely distributed to be of any economic use.

Limestone

Ajmer-Merwara.

Mr. B. N. Sinha reports a narrow, impure limestone band near Gudha (74° 46′ : 26° 29′ 15″). About a mile to the west of Maila (74° 34′ : 26° 9′ 15″), another 150 feet wide band of impure limestone was also noticed.

Abor Hills, Assam.

Dr. A. K. Dey reports the occurrence of argillaceous limestones inter-bedded with sandstone, shale and lava flows in the valley of the Dihang near Rengging (28° 08′ : 95° 17′) six and half miles north-west of Pasighat, Abor Hills, Assam.

Three samples on analysis in the Geological Survey of India laboratory show :—

	CaO	MgO
1	21·03	15·12
2	25 84	18 30
3	20 76	16·08

Mikir Hills, Sibsagar and Nowgong districts, Assam.

Mr. D. K. Chandra investigated the limestone occurrences in the Mikir Hills, Assam, with a view to determining the possibility of a cement industry in Assam. The area examined is confined to the boundary-zone between the two districts, Nowgong and Sibsagar. The outcrops are scattered over an area bounded by latitudes 25° 54′ and 26° 5′ 30″, and longitudes 93° 9′ 30″ and 93° 40′ 30″, falling in sheets 83 F/4, 8, 12 and 83 G/1, 5 and 9.

Some of the limestones contain a fairly high percentage of iron. Bauxite of high alumina-content will be required to be added to increase the alumina-content in the raw mixes for Portland cement, so that the ratio of percentage of iron-oxide to that of alumina does not exceed 1 5. The limestone of high iron-content may be utilised for the manufacture of "Ferro-Portland" cement which may be useful for cementing oil-wells or for other purposes where water of high salinity must be excluded.

The high silica limestone may be suitably used for Natural cement, provided other constituents are present in the right proportions.

The total reserves of limestones available are:—

(1) For 'Natural' cement	6 million tons.
(2) For Portland cement	85 million tons.
(3) For Portland cement (bauxite to be added to the raw mixes)	63 million tons.

The Loila Pahar—Dilai Parbat area has, according to Mr. Chandra, the best potentialities for Portland cement manufacture, so far as the quality and quantity are concerned. This area alone is in a position to supply limestones for about 350 years for a single factory with a production capacity of 500 tons of cement a day.

Amraoti district, Central Provinces.

Mr. S. M. Mathur records interrupted outcrops of limestone along the outer Chikalda Range, Amraoti district, from Belkher (21° 22′ : 77° 31′) to Bairam Ghat (21° 22′ : 77° 37′). In general the limestone is cherty, but a purer variety, suitable for burning for lime, also occurs at some places.

Nagpur district, Central Provinces.

Mr. P. K. Chatterjee records a small exposure of hard and cherty infra-trappean limestone on the Nagpur-Betul road, north of Chicholi Rest House (21° 30′ : 78 42′). Two similar occurrences are present near the western border of Kelod (21° 28′ : 78° 47′) and E.N.E. of Jaitgarh tank (21° 29′ : 78° 48′).

East Godavari district, Madras.

Mr. V. Subramanayan carried out a detailed investigation of the limestone deposit near Bhumanlanka (18° 4′ 30″ : 80° 45′ 45″), sheet 65 B/16, about one and a half miles east of Cherla (18° 4′ 40″ : 80° 49′ 30″), in the East Godavari district and took representative samples from across the deposit for analysis in order to estimate its utility for the manufacture of cement for the Ramapadasagar dam on the Godavari river near Polavaram.

There are two exposures of the limestone: (i) A prominent exposure to the north of Bhumanlanka extending for a distance of about three and a half furlongs and having a maximum width of about 220 feet. This is on the right bank of the Talperu river, a tributary of the Godavari river and east of the quartzite hill east of Cherla; (ii) A small exposure on the left bank of the Talperu river and about two furlongs E.S.E. of Bhumanlanka. This exposure is 350 feet × 250 feet in area and appears to be the continuation of that on the western side of the Talperu river.

The limestone is fine-grained and varies in colour from grey to dark tints. It is in places slaty or shaly and specks of pyrite are common. The limestone occurs in association with calcareous quartzites and shales. On account of some faults cutting obliquely across the deposit, the limestone is exposed in the form of disconnected patches. The general strike of the limestone deposit north of Bhumanlanka is N.N.E.-S.S.W. with a dip of about 60 to 70 degrees to the E.S.E. or W.N.W. On the left bank of the Talperu, an E.-W. strike with a dip of about 70 to 75 degrees to the north or south has been observed.

Assuming the whole of the limestone to be of workable quality a total reserve of about 5 to 6 *lakhs* of tons can be expected from the above exposures within a depth of 20 feet from the surface. The covered areas north and east of the limestone deposit and around Bhumanlanka are likely to contain some limestone and this will have to be proved by means of bore-holes.

Guntur district, Madras.

Mr. N. V. Chandrasekariah reports an occurrence of *kankar* in fair abundance in the area, comprised in sheet 56 P/16, of the Guntur district. The material is extensively used for lime-burning, and when compact and fresh it is also used in blocks as building material.

Mr. S. N. Sen examined occurrences of limestones and calcareous phyllites about three miles E.N.E. of Mugachintalapalem (16° 1′ : 79° 42′); these bands, with a total width of about a furlong, run for half a mile. Another important outcrop of limestone was noted north of Mannepalle Konda (·1608), about six miles north-west of Bollapalle (16° 11′ 10″ : 79° 41′ 20″), sheet 56 P/12. Here the bands run for about six furlongs and the total width of the outcrop is about two furlongs, but bands on the eastern half are more siliceous.

Bands of limestone and calcareous phyllites are noted west of Moddala Konda at about a mile east of Kanamalacheruvu. They run for about six furlongs. The bands approaching

Moddala Konda are more siliceous. About four and a half miles north-west of Kanamalacheruvu another set of limestone outcrops are noted north and west of Kandurla Konda (·1138). Here the bands occur at intervals and also are intruded by quartz-veins.

Ramnad district, Madras.

The limestone deposits near Pandalkudi (9° 23′ 45″: 78° 6′ 20″), 8 miles south of Aruppukkottai at the western part of Ramnad Zamindari in Ramnad district were investigated by Mr. Narayanaswamy along with Mr. V. Gopal, during the first week of March 1948. The limestone here occurs as a band, 200-275 feet in width, extending in a N.W.-S.E. line for a length of nearly four miles to the south, west and north-west of Pandalkudi village. Except for the eastern 50-75 feet of the width and the northern one mile length of the band which carry some impure pink coccolitic material, the greater portion of the band is composed of coarse, white, calcitic limestone and admixed beds of finer-grained marbles and banded carbonaceous (graphitic) limestone. The probable minimum reserves of good quality material for an assumed depth of ten feet and on the basis of 13 cubic feet per ton will be about 340,000 tons. The limestone is very well suited for cement manufacture and lime-burning.

Mr. N. K. N. Aiyengar reports an occurrence of *kankar* to a depth of four to five feet all along the Kallar river north of Panaimadal village (11° 43′ : 78° 28′). As a large quantity of this material is available it is worth-while to test its suitability for lime-burning.

According to Mr. A. S. Ramiengar large tracts in Attur *taluk* contain *kankar* to some depth. It may be tested as regards its suitability for lime-burning.

Mr. S. Narayanaswami has examined bands of crystalline limestones of varying dimensions and composition: (1) at Nagalapuram (8° 59′ 59″ : 77° 44′ 0″) (2) between Kayattar (8° 57′ 0″: 77° 46′ 30″), Kalappaipatti (8° 52′ 45″ : 77° 49′ 0″), Singattakkurichchi (8° 47′ 15″: 77° 53′ 0″) and Deyvachchilaipuram (8° 44′ 15″ : 77° 55′ 15″), (3) at Tattapparai Railway station (8° 49′ 40″ : 78° 1′ 30″), (4) near Eppodumvenran (9° 1′ 10″ : 78° 3′ 0″), (5) adjoining Podupatti (9° 2′ 30″ : 77° 59′ 0″), (6) near Villiseri (9° 2′ 45″ : 77° 48′ 30″), (7) north of Semmapudur (9° 5′ 20″ : 77° 57′ 30″), (8) at Ilambhuvanam (9° 9′ 0″ · 77° 58′ 15″), (9) around Pudur (9° 17′ 30″ : 78° 8′ 15″), and other places. The bands carry fair quality coarse-grained calcitic limestones with admixed impure magnesian limestones and calc-granulites. The majority of the bands are thin and irregular in distribution and are of use only for local lime-burning purposes. The band at Nagalapuram carries some high-grade limestone and has been already reported to contain about 40,000 tons (for 20 feet depth) of good material suitable for cements and chemicals.

Tinnevelly district, Madras.

Mr. J. Narayanamurthy reports occurrences of bands of crystalline limestone of varying dimensions and composition at Kalappaipatti, Nagalapuram (9° 14′ 0″: 78° 8′ 0″), Pudur (9° 17′ 30″: 78° 8′ 15″), Kaiyattar (8° 57′ 0″: 77° 46′ 30″), Eppodumvenran (9° 1′ 10″: 78° 3′ 0″), and Villiseri (9° 3′ 0″: 77° 48′ 30″). The majority of the bands are, however, thin and irregular.

Mr. S. Narayanaswami reports the frequent occurrence of beds of concretionary *kankar*, up to one to two feet thick, along many of the stream courses all over the black-soil area of the Tinnevelly district. These are used locally for lime-burning, etc., and are of no more economic value.

Maihar State, Vindhya Pradesh.

Mr. G. V. Rao examined the Vindhyan limestones in the Maihar State. According to him the Rhotas limestone is very well developed in the State and occupies a wide area. The limestone is extensively used both for lime-burning as well as for the manufacture of Portland cement.

The Bhander limestone also supports a vast lime industry in the State and is present over a large area but is covered by alluvium at many places. In some of the existing quarries the overburden of soil is up to 12 feet in thickness.

Manipur State.

Mr. T. Banerjee records occurrences of extremely fine-grained and somewhat brittle limestone in pockets at the undermentioned localities in Manipur State, with available tonnages as follows:

1. Ukhrul area (94° 22′: 25° 07′) between milestones 31 and 44 on the Imphal Ukhrul Road
   (a) Near Ukhrul: 200,000 tons.
   (b) Near Lambui (94° 17′: 25° 01′): 500,000 tons containing 45 54 per cent. CaO.
   (c) Hungdung (94° 02′ 30″: 25° 04′): two million tons containing 52 98 per cent. CaO.
2. Taupokpi, near Shuganu (93° 53′: 24° 17′ 30″): 120,000 tons containing 44·33 per cent. CaO.
3. Near Yaithibi (94° 02′: 24° 31′): Very small tonnage.
4. Near Lamgang Khunou (94° 04′: 24° 24′): 160,000 tons containing 34·12 per cent. CaO.

Calc-tufa, Ganjam district, Orissa.

Mr. G. H. S. V. Prasad Rao records occurrences of calc-tufa in cracks and fissures of granulitic rocks along a *nala* bank just by the side of the road leading from Naugad (84° 03′ : 19° 06′) to Khijuripada (84° 06′ : 19° 04′). The material is burnt locally and yields 40 per cent. lime after calcination.

Kankar, Ganjam district, Orissa.

Mr. Y. G. K. Murty visited a number of places for investigating the *kankar* occurrences of the Ganjam district. The maximum depth to which *kankar* is disseminated in the soil is four feet. The kankar-bearing soil is not uniform even for short distances and concentration of the material is very poor, usually of the order of five per cent. by weight of the soil in which it occurs.

Mirzapur district, United Provinces.

Mr. Mukti Nath was deputed to investigate the Kajrahat limestone, in Mirzapur district, United Provinces, with a view to determining its suitability for the manufacture of Portland cement. From the commencement of the field-season up to about the middle of January 1948, he confined his attention to the area south of the Son river, as near the Rihand dam as possible (sheets 63 P/2 and 3).

Mr. Mukti Nath reports that the Kajrahat limestone extends between the Rihand river in the west and Hardi village (24° 27′ : 83° 11′) in the east, a distance of about 15 miles. The limestone occurring at the base of the Kajrahat stage appears to be of better quality than that composing the upper stage, which is rather dolomitic. About 30 samples were analysed, and of these, eight samples contain MgO lower than three per cent. and may be considered suitable for the manufacture of cement. Mr. Mukti Nath is of the opinion that the limestone at Kota (24° 27′ : 83° 07′) may last for over 100 years for a cement factory producing 250 tons of cement per day.

Some of the samples contain 94 to 95 per cent. calcium carbonate and under three per cent. silica. These samples represent the entire width of the outcrop and if proper sampling is made band by band, it would probably be possible to get bands of pure limestone suitable for chemical lime. Mr. Mukti Nath is of the opinion that if a sufficient quantity of pure limestone is available, the deposit may be reserved for the manufacture of chemical lime.

Mr. Ahmed has located a deposit of marble north-west of Garia (24° 8′ : 82° 58′) containing over one million tons of marble.

(See also pages 157-159.)

Magnesite

Salem district, Madras.

Besides the well-known magnesite of Salem, Mr. N. K. N. Aiyengar reports a small patch of magnesite-bearing rock (100 feet × 100 feet) about a mile north-west of Singiliyan-Kombai (11° 32′ : 78° 25′) village. The occurrence is of little economic importance.

Almora district, Kumaon hills, United Provinces.

Mr. Mukti Nath records the occurrences of crystalline magnesite at Boragar (29° 43′ : 80° 03′), Ganai (29° 43′ : 79° 57′), Phadyari (29° 43′ : 79° 55′), Rithait (29° 42′ : 79° 59′), Tachhni (29° 47′ : 79° 51′), Jajurali (29° 46′ : 79° 52′) and Dewaldhar (29° 47′ : 79° 45′), etc., in the Kumaon hills, Almora district. The mineral occurs in association with dolomitic limestone and talcose materials. The quality of the magnesite varies widely in different parts of the deposits, but Mr. Mukti Nath is of the opinion that on detailed prospecting a considerable quantity of good quality magnesite may be obtained from these deposits.

Manganese-ore

Patna State, Orissa.

Mr. S. Krishnaswamy examined 22 localities for manganese-ore in the Patna State. The manganese-ore bodies examined by him are associated with the khondalitic suite of rocks represented by garnetiferous biotite-gneisses carrying little or no sillimanite, garnetiferous-quartz-sillimanite rock showing specks of graphite (khondalite), and thin bands of light grey calc-gneiss and calc-granulite. Concentration of the manganese-ore in the country rock appears to be greatest where the calc-granulite bands are most numerous. Psilomelane is the common ore but occasionally a little pyrolusite and wad may also be found. Analyses of representative samples collected from various parts of the State show that most of them can be classified as ferruginous manganese-ore. On an average the samples show the following range in composition:—

Mn	25·45 per cent to 33·52 per cent.
Fe_2O_3	23·83 per cent to 33·59 per cent.
SiO_2	7·35 per cent. to 10·20 per cent.

From the various large occurrences of the Patna State the total quantity of manganese-ore obtainable from within a depth of 50 feet below the surface is about 650,000 tons. According to Mr. Krishnaswamy these deposits cannot be worked economically at present firstly because of the poor quality of the average ore, and secondly because they are distantly situated from the nearest railhead. The more important deposits occur at Gadshanker (20° 47′ : 33° 20′), Bhaludungri (20° 46′ : 83° 19′), Andhari (20° 50′ : 83° 15′), Satparliadungri (20° 50′ : 83° 20′), Kapilbahal (20° 46′ : 83° 16′), Kumiapali (20° 46′ : 83° 16′) and Kaniamanga (20° 48′ : 83° 14′).

Rairakhol State, Orissa.

Mr. S Krishnaswamy has examined three small pockets of manganese-ore lying within a radius of one or two miles of Kandhal (21° 03′ : 84° 10′), in the Rairakhol State. The material consists of a low grade ferruginous manganese-ore with 25·43 per cent. manganese on an average. The total reserves calculated for a depth of 50 feet are about 60,000 tons. The deposits occupy steep slopes of high hills about forty miles from the nearest railhead and cannot be economically worked at present.

Mica

Kistna district, Madras.

Dr. M. S. Krishnan examined the mica-pegmatites in the Tiruvur *taluk*, Kistna district, Madras. Shallow quarries worked for muscovite are found in the following places :—

(1) About three furlongs west of the southern end of Tiruvur village (17° 7′ : 80° 37′) excellent clear ruby mica up to 10 or 11 inches across is got. (2) Just west of the main road at Lakshmipuram (17° 4′ 30″ : 80° 37′ 30″) which is two and a half miles south of Tiruvur. This yields light ruby mica which is spotted. (3) At the foot of the hills one and a three-fourth miles due west of mile-post 29 on the main road. The mica is pale green, clear and spotted, up to five or six inches across. (4) Near Gampalagudem (17° 0′ : 80° 31′ 30″). Good quality mica is reported to be worked, but the locality was not visited.

Excellent indications of workable deposits are seen one mile south-west of Tiruvur; near Repudi and Kummarkuntla (16° 56′ 30″ : 80° 40′ 30″), near Chimalpadu (16° 53′ : 80° 39′) as well as east and north of Konduru (16° 58′ : 80° 39′), but none of these have yet been opened up. The whole region is worth detailed examination.

Ganjam district, Orissa.

Mr. G. H. S. V. Prasada Rao records the occurrence of small flakes of muscovite up to one square inch in size in a pegmatite traversing granite-porphyry, on the northern flank of a hill about one and a half furlongs S.S.E. of Rangad (18° 57′ ; 84° 14′), According to Mr Y G K Murty mica-bearing pegmatites are present near Dwaragam (19° 20′ 84° 32′), Adaba (19° 29′: 84° 11′) and Mohana (19° 26′ 84° 16′) The pegmatites are small in size and poor in mica. The quality is not good and the maximum size of the books is five inches across.

Mineral Pigments

Ochre, Nagpur district, Central Provinces.

Mr. P K. Chatterjee examined an occurrence of yellow ochre in a band of argillaceous sandstone south-west of Khairi (21° 9′: 78° 49′). The material is worked for local use.

Ochre, Ceded district, Madras.

Mr. V. Venkatesh records occurrences of yellow ochre of apparently good quality in weathered Owk shales near Uyyalavada (78° 4′ 40″: 15° 37′ 40″) and Loadipalle and a mile south of Kristnapuram (78° 2′ 30″: 15° 35′ 30″). A few pits were also observed in these localities.

Ochre, Ganjam district, Orissa.

Mr. G. H. S. V. Prasada Rao noticed red ochre occurring in pockets in the laterite resulting from the alteration of khondalitic rocks at Kurumu (19° 04′: 84° 13′). The ochre is of very poor quality and contains much gritty material.

Mr. Y. G. K. Murty records occurrences of red ochre in the laterite about three furlongs N.N.E. of Hachhipanga (19° 23′: 84° 9′). The material occurs on the top of a hillock about 1,500 feet above the surrounding country.

Ochre, Datia State, Vindhya Pradesh.

Mr. M. K. Roy Chowdhury records occurrences of red ochre at many places in the ferruginous shale of the Morar group between Gumanpura (26° 14′: 78° 47′) to the east and Bara Ratanganj (26° 10′: 78° 39′) to the west. At present a three to four-foot bed of ochre is being mined by Messrs. Prakash Industries at Bara Ratangarh. The present output is about 2,000 maunds per month. The material is suitable only for colour-wash.

Petroleum

Assam and Tripura State.

Dr. A. K. Dey and Mr. V. H. Boileau visited the Digboi oil-field and the test-locations at Tiru (26° 52′: 94° 54′) in Sibsagar district and Masimpur (24° 52′: 92° 46′) in Cachar and Rokhia near Putia (23° 39′: 91° 12′) in Tripura State for technical discussions with the Assam Oil Co. Ltd., and the Burmah Oil Co.

(India Concessions) Ltd., and submitted a joint report on matters relating to oil development in India.

Kangra district, East Punjab.

Mr. V. H. Boileau, Petroleum Geologist, accompanied by Mr. G. Kohli visited Jawalamukhi (31° 53′:76° 19′) and Kangra (32° 6′ : 76° 16′), Kangra district, to verify in the field certain structures suggested by some earlier traverses, which appeared to be suitable as oil-traps.

The Jawalamukhi gas seepage has been known for many centuries, and supplies the fuel for the sacred fire in one of the temples at that place. Oil and bitumen are also known to be associated with the salt intrusions north of Mandi to the east, and the Attock fields lie further along the same Tertiary belt to the north-west.

This region is one of the farthest in the Indian Union from a port, hence one where indigenous sources of supply would be most valuable.

Preliminary studies suggested that the Jawalamukhi structure is of the same general type as occurs in the Persian oilfields, and that the gas escapes along a thrust-plane from an underground reservoir situated some miles to the north-east. Reconnaisance in April, 1948, confirmed that structural type, and located a secondary fold behind the thrust outcrop, which may have trapped some of the gas.

A detailed survey is being carried out in the field-season 1948-49 with a view to assessing the possibilities more accurately. In the event of the discovery of an oilfield here, several other structures in the same region will also require investigation. Geological evidence alone may prove insufficient, and geophysical surveys may be needed to supplement it before any drilling can be recommended.

Quartz

Singhbhum district, Bihar.

Several vein quartz deposits near the Pandrasali Station of the B. N. Railway, have been examined in detail by Mr. R. N. P. Arogyaswamy.

The Porloyang deposit (22° 40′:85° 48′) is located about two and a half miles north of the Pandrasali railway station and about one furlong to the east of Porloyang village. This is a very conspicuous high hill, rising about 150 feet above the general country. A fair motorable road connects the deposit to the railway station.

A rough survey was made with compass and aneroid in order to estimate the amount of material available in this hill.

Assuming the working depth to be 20 feet the net reserve of the Porloyang deposit has been estimated at 103,000 tons.

The Bicha Gutu deposit (22° 39′:85° 48′) is a small quartz hill about one mile north-west of the Pandrasali railway station, and there is a *Kutcha* road connecting this deposit to the main road from Chaibassa to Kharswan. The general trend of the vein is east-north-east—west-south-west, *i.e.*, 240° and there appears to be a very steep dip to the north-north-west, *i.e.*, 330°. The average width of the vein is between 10 and 15 feet at the eastern end, where it is also of good quality; but towards the western end it seems to become more contaminated with ferruginous stains.

The net reserve to a depth of 20 feet has been estimated at 12,000 tons in the Bicha Gutu deposit.

In two other neighbouring veins 9,000 tons of the material will be available.

The Sangajata deposit (22° 38′:85° 51′) is situated just north of the Sangajata village and is easily accessible from Pandrasali station.

In general this deposit is similar to those that have been already described. The estimated reserve is 149,000 tons.

The deposits can be easily worked by open cast mining. The material is good quality quartz and well suited to industries requiring a high grade of purity, *e.g.*, silica glass, white enamel or pottery (glazing).

Vein quartz; Salem district, Madras.

A large number of white quartz veins suitable for use in the glass industry have been recorded around Singiliyankombai (11° 32′:78° 25′) and Isvaramurthipalaiyam (11° 34′: 78° 24′) by Mr. N. K. N. Aiyengar in the course of his systematic geological mapping of the Salem district, Madras.

Mr. A. S. Ramiengar records a large vein of white quartz east of Siliyampatti (11° 34′: 78° 31′). According to him this may yield quartz of a suitable quality (nearly free from iron) sufficient for a small glass factory.

(See also pages 94-95.)

Salt

Manipur State.

The manufacture of salt from brine wells in a crude way is still a small cottage industry in some parts of Manipur State During the field season 1947-48, Mr. T. Banerjee visited some 16 localities in the valley of the Thoubal river in the area bounded by long. 94° 05′ and 94° 10′ and lat. 24° 38′ and 24° 48′. He observed that the springs are worked by digging shallow wells around them in which hollowed trunks of big trees are later inserted for support. The depth of the wells depends on the thickness of the soil capping. The yield from the brine springs was found to be insufficient for further expansion of the industry which, however, meets the local demand.

Steatite

North Arcot district, Madras.

Mr. B. Srikantan reports occurrence of impure steatite in the northern part of the Walajah *taluk* of the North Arcot district. The material is not of sufficient purity or extent to enable it to be used for purposes other than its present use, *i.e.*, in pottery and utensils.

Kurnool district, Madras.

Mr. V. Venkatesh reports occurrence of steatite in the R. F., 1¾ miles north by west of Gadidemadugu (78° 9′:15° 46′ 30″). It is light greenish grey to white in colour and occurs as segregations and lenses associated and interbedded with Vaimpalli limestones. There are three fair sized pits in this area; but it is difficult to estimate the reserves due to the irregular distribution of the mineral.

Salem district, Madras.

A large number of outcrops of steatite-bearing rock have been recorded by Mr. N. K. N. Aiyengar in the hillocks south of Singiliyankombai (11° 32′:78° 25′) and east of Isvaramurthipalaiyam (11° 34′:78° 24′). The material is not of high grade. Local people use it on a fairly large scale in making utensils.

Sulphur

Salem district, Madras.

Mr. N. K. N. Aiyengar has noticed yellow incrustations on the quartzites along the railway cutting about two furlongs east of Seshan Chavadi. Such beds have been found in several places. According to Mr. Aiyengar these are of no economic importance.

Triplite

Ajmer-Merwara.

Mr. B. N. Sinha reports occurrence of triplite in association with hematite in an abandoned mica quarry, a little more than a mile to the east of Tihari (74° 54′:26° 24′) and in the two pits to the south of Sanod (74° 50′:26° 17′ 15″).

IV. SPECIAL INVESTIGATIONS

GEOPHYSICAL SECTION

The following is a brief account of the main field activities of the Section during the year:—

Investigations by Electrical Resistivity Method in the Kamptee area (Nagpur).—As reported last year, investigations by electrical resistivity methods were started in the Kamptee area with a view to demarcating the boundary between the Gondwana sedimentaries (possible coal-bearing formations) and the surrounding Archæans (non-coal-bearing rocks) which is everywhere covered by alluvium. This was to enable the Provincial authorities, who were planning to undertake borings on a large scale, to confine drilling to within the limits of the Gondwanas and avoid unnecessary expenditure. This work was continued from January to March, the party consisting of Mr. P. C. Paul, Geophysical Assistant (in charge), assisted by Mr. K. R. M. Simha, Instrument Operator and R. N. Biswas, Surveyor.

At the time of discontinuing the work during the previous year more than 30 km. of boundary had been traced in an area of about 50 sq. km. bounded by latitudes 21° 22′ and 21° 20′ and longitudes 79° 10′ and 79° 17′ 30″. The boundary revealed by geophysical survey fairly corroborated the expectations based on the scanty geological evidence.

Apart from the determination of the aforesaid boundary, the geophysical party also tried some experiments regarding possible electrical indications which would help to differentiate the actual coal measures from the barren Gondwana sediments. The values of several resistivity soundings were somewhat higher than the average, which may be indicative of the presence of coal seams; however, the order of other irregularities of the curves are not small enough to warrant the use of such indications in actual coal prospecting.

The widely differing resistivity values of the sediments, brought out in traverses, cannot be ascribed to one single stage of the Gondwanas, but may be taken as signifying different stages in lateral sequence.

Jogighopa, Assam.

Determinations of Depths to Bed-rock by Seismic and Electrical Resistivity Methods,—The only railway route to upper Assam suffers from frequent dislocations of the Manas bridge due to the devastating floods of the Manas system of rivers. The hydrological and geological conditions of the catchment area of these rivers are not suitable for implementing any permanent flood-control device.

The railway authorities, therefore, have under contemplation the construction of a bridge over the Brahmaputra itself further west and down stream.

In order to decide if the piers of the bridge could be built on a solid foundation, it was necessary to determine the depth of the bed-rock below the river-bed. Several borings were put down, but these failed to meet the bed-rock, being obstructed by a shingle-bed. It was thought that geophysical methods might provide the necessary information.

The party consisted of Mr. L. N. Kailasam, Geophysical Assistant (in charge), assisted by Mr. M. A. Anandalwar, Assistant Geologist, Mrs K. M. Sarma and Mr. P. M. Mathew, Geophysical Assistants and Mr. T. S. Ramachandran, Instrument Operator.

Dr. G. Dessau, Geophysicist and Mr. A. Del Carlo, Geophysical Technician were also present for some time. The work was carried out during the months of January and February.

The electrical resistivity method was first used, "soundings" and "constant separation traverses" numbering ten in all being carried out. The sounding curves mostly approximated three-layer cases and they were satisfactorily interpreted by comparison with theoretical three-layer curves.

On account of the great importance attached to the proposed engineering structure the results of the electrical survey were checked by a "Refraction Seismic" method using a military sound-ranging equipment, modified for the purpose in the Department's geophysical workshop. With only three available channels for the instrument, the actual bridge alignment was explored in detail with shot-points every 240 metres and geophones every 60 metres. The quantity of explosive (gelignite) used varied from a few ounces to over five pounds.

The results obtained from the above two independent geophysical surveys agreed fairly well. The depths to bed-rock were decidedly unsuitable for the foundation of the piers on it.

Pargaon, Kopargaon and Idgaon, Bombay Presidency.

While carrying out investigations near Poona for water in the Deccan trap (see below), the geophysical party was approached by the local P. W. D. authorities with a request to carry out some resistivity measurements on the river-beds of the Bhima, Godavari and Tapti at Pargaon (Poona district), Kopargaon (Nasik district) and Idgaon (East Khandesh district)—all in the Bombay Presidency, with a view to determining the depth to bed-rock for bridge-foundations.

The party, consisting of Mr. S. N. Sen Gupta, Geophysical Assistant (in charge), assisted by Mr. A. Roy, Geophysical Assistant, Mr. T. S. Ramachandran, Instrument Operator and Mr. R. N. Biswas, Surveyor, carried out the work during the months of May and June.

In spite of transport difficulties and having to work with new, untrained *coolies* each time, it was possible to complete the work at all the three places in less than four weeks. The results showed that the depths to bed-rock for the rivers Bhima and Godavari at Paigaon and Kopargaon respectively were suitable for bridge-foundations; but no hard bed-rock was indicated within 100-150 metres for the river Tapti at Idgaon.

The above results also show that the time and cost needed for investigations of this kind by geophysical methods are unbelievably low as compared with explorations by borings.

North Tirodi, Balaghat district, Central Provinces.

Prospecting for Manganese-ore by Magnetic Method.—A geophysical survey was undertaken with a view to locating fresh deposits of maganese-ore occurring in the gondite series of the Dharwar System (Archæan), at the request and expense of the Central Provinces Manganese Ore Company.

The party, consisting of Mr. R. A. Nagarajaiah, Assistant Geologist (in charge), Messrs. A. Roy, S. N. Sen Gupta and P. C. Paul, Geophysical Assistants and Mr. A. K. Sen, Instrument Operator, carried out the work during the period January to October.

Measurements were made along two sets of orthogonal profiles (east-west and north-south). Readings were taken at more than 3,000 stations in an area of about three-fourths of a square kilometer. The horizontal magnetometer, made at the geophysical workshop, was comparatively low in sensitivity and hence was used only in places where vertical intensity measurements signified the possibility of a big horizontal anomaly.

The data were interpreted and about a dozen points, based on geophysical indications were suggested for the sinking of trial pits. Excepting one, all the pits struck ore at or near the calculated depths. The above survey was supplemented by some electrical resistivity and spontaneous polarisation measurements, with a view to examining the possibilities of the two latter methods for such work. The results indicate that although some concordant results were obtained by the resistivity work, the magnetometer is the most suitable instrument for this type of work.

Dandatapa, Athmallik State, Orissa.

Spontaneous Polarisation Survey for Graphite deposits.—The khondalites are characterised by the presence of small flakes of graphite as a constant accessory. But the occurrence of deposits of graphite in workable quantities in these rocks seems to be connected with the pegmatite or granitic intrusions. A geophysical survey was undertaken to ascertain if such graphite deposits are amenable to spontaneous polarisation measurements.

The party consisted of Mr. S. C. Sinha, Instrument Operator (in charge), Mr. S. C. Chakravarty, Assistant Geologist and Mr. H. C. Ganguly, Surveyor. The work lasted for four months from January to April.

Parallel profiles, at every 20 metres, were laid out across the general strike, on both sides of the Dandatapa mine. Natural potentials were picked up by two non-polarisable electrodes and measured by a potentiometer. One of the potential pick-ups, the reference electrode, was kept at the same place throughout the survey. About 3,000 stations were measured over an area of about 0·6 square kilometre.

Trial trenches were put down in the three strongest negative located. They follow the strike of the local formations and must therefore be connected with some particular horizon within the same.

Trial trenches were put down in the three strongest negative centres; but owing to the presence of big boulders, they had to be discontinued at shallow depths. In the middle trench, however, which was sunk to a depth of 12 metres, the graphite was found to be associated with felspar. The same association was noticed at a similar depth in a mine in the adjoining area. The nature and association of the material are typical, and differ from the flaky dissemination usually met with in the khondalites.

Dr. Dessau is of the opinion that the survey has conclusively proved the usefulness of the spontaneous polarisation method for indicating emplacements for exploratory workings for graphite, under conditions prevailing in this part of the country.

Shergarh-Phalsund area, Rajputana.

Prospecting for Ground-Water by Resistivity Method.—In highly arid regions like Jodhpur in West Rajputana, the problem of determining the depth of the water-table and the thickness of the water-leading zone, and also of differentiating between the underground sources of fresh and brackish waters, are of great importance. The electrical resistivity method was employed with a view to exploring the extent to which it could be used for such investigations.

The party consisted of Dr. F. Ermisch, Geophysicist (in charge), assisted by Messrs. G. N. Dutt and M. A. Anandalwar, Assistant Geologists, Mr. P. M. Mathew, Geophysical Assistant, Messrs. S. C. Nandy, T. S. Ramachandran, Instrument Operators and Mr. P. L. Gangopadhya, Surveyor. The work was carried out during the months of January to May, and September to December.

On the advice of the Public Works Department of Jodhpur State, a belt stretching east-west along the Shergarh-Chaba-Phalsund Road was selected with the primary idea of tracing the boundary between fresh and brackish waters. It was, later on, found that there was no fresh water at all, everywhere the ground-water being more or less saline—a fact which rendered the geophysical survey most difficult. "Electrical soundings" were carried out at the wells within reach; and then a continuous line of soundings, on the average a mile apart, all the way from Shergarh to Phalsund, was taken, often connecting the soundings by "constant separation traverses". The electrical sounding curves follow the same broad pattern and roughly approximate three-layer curves of high-low-high type. The curves indicate that the water-bearing zone is extremely thin and under such circumstances the electrical sounding curves lose most of their discriminatory significance. However, they help to distinguish empirically certain "types". For instance, the general character of the curves was fairly constant along the belt between Shergarh and the outskirts of Phalsund, and along this stretch conditions are known to be uniformly unfavourable. Recognition of this type of curves is useful in giving information regarding the inadvisability of sinking wells under certain conditions.

Dr. Ermisch is of the opinion that the area has no continuous water-table, and that the little rain-water which seeps in, collects on the top of the rhyolite floor in several depressions forming small basins. Only the presence of small reservoirs, separated from one another, could explain the marked and erratic differences in salinity between neighbouring wells. Cases were revealed in Phalsund area where a thin layer of drinkable water floated on brine.

As it was felt that geophysical investigations were by no means enough for getting sufficient knowledge of the hydrology of this desert area, additional information was collected regarding the level and depth of water in the wells, its temperature and salinity, and the variation of the latter with depth.

Dhond, Poona district, Bombay Presidency.

Well-sinking in Deccan trap areas involves a good amount of risk due to the high cost of blasting and the uncertainty of striking water. Considering the extensive area covered by the traps, it is important to investigate if the problem of water supply in these areas can be approached and studied by geophysical methods.

The party consisted of Mr. S. N. Sen Gupta, Geophysical Assistant (in charge), assisted by Messrs. A. Roy and P. C. Paul, Geophysical Assistants, Mr. S. C. Nandy, Instrument Operator, and Mr. R. N. Biswas, Surveyor. The work was carried out during the months of March to July, and again in November and December.

The area around the town of Dhond had been selected on geological advice for preliminary investigations. The geophysical party completed five electrical soundings and five kilometers of constant separation traverse, in addition to carrying out some measurements of absolute resistivity of Deccan trap basalt. The sounding graphs do not give any clear indication of a water-table, although one of the traverses has revealed two clear zones of lower resistivity.

Data obtained in the course of the investigation are yet inconclusive, and the work will have to be carried on for a long time over wide areas before any general conclusion can be arrived at.

DRILLING SECTION

Bengal and Bihar coalfields.

In connection with the sand stowing programme for the conservation of coal and the safety of mines in the Bengal and Bihar coalfields, the Geological Survey of India, in order to obtain a reasonable estimate of the reserves of river-sand within the Raniganj coalfield, carried out systematic drilling operations in several selected portions of the beds of the Damodar, Barakar and Ajoy rivers, under the supervision of Mr. A. B. Dutt, assisted by Mr. D. M. Sen and Mr. P. N. Ghosh.

The work was taken up in the Damodar river in the middle of November, 1946 and after being continued through the subsequent field season was brought to a close in the Ajoy river in the middle of June, 1948. Altogether 186 holes were drilled, depths ranging generally between 20 and 40 feet in the Damodar and Barakar rivers, and 15 to 25 feet in the Ajoy river. The positions of the bore-holes, together with the thickness of sand proved in each hole, have been plotted on the 4″=1 mile scale map and systematically tabulated.

For the purpose of calculating the reserve of sand the area in each of the river-sectors examined was subdivided into blocks and the average thickness of sand in these was calculated from the bore-hole data.

Ondal, Burdwan district, West Bengal.

Drilling was also carried out in the East Raniganj coalfield (Ondal area) in connection with the investigations of coal for the manufacture of synthetic petroleum (see page 80).

EXPLORATORY MINING SECTION

Copper deposits of Sikkim.—The following examination of ancient copper workings in Sikkim by Mr. D. Kerr-Cross, Mining Engineer, was of an exploratory nature, and carried out with a view to planning further detailed work, where necessary.

Mr. Kerr-Cross along with Dr. A. K. Dey, Superintending Geologist and Dr. G. Dessau, Geophysicist visited the area in the month of April.

The more important ancient workings lying in the eastern section of Sikkim were visited and, where possible, access gained to the old underground workings. The absence of reliable, large-scale maps of the district showing the exact localities of the various occurrences, rendered their location difficult. Also, when they were located the majority of these old workings were found to be inaccessible owing to the ground having caved.

Dikchu.

As far as could be seen the occurrence at Dikchu was never worked by the ancients; but Messers. Burn & Co. of Calcutta carried out work there in or about the year 1909. The old workings are in the vicinity of the Gangtok-Dikchu pack road, about nine miles to the north of Gangtok.

Two adits had been driven into the base of steep sided hills from the valley lying to the east of the pack road by Messrs. Burn & Co.; but only one of these was examined at the time of the visit as the existence of the second and apparently more important one was not known at that time. The adit inspected is only 15 feet long with a bearing of 170° (S 10° E.) and had been driven on indefinite vein-matter consisting of sporadically occurring quartz with minute stringers of chalcopyrite in schist. The copper-content of samples taken and examined was found to be invariably rather low.

There is evidence of an old incline higher up on the hill side in the vicinity of the pack road. This, however, is filled with debris to within a few feet of its mouth. Quartz occurs here as occasional "blobs" with only traces of chalcopyrite.

According to Mr. Pellow-Harvey, a mining engineer who reported on the property in 1909, the second of the two lower adits mentioned above was driven in a northerly direction for a distance of 177 feet, and 11 samples collected by him from there averaged 7½ per cent. Cu over a width of 40 inches. It is unfortunate that the party were unaware of the existence of this adit, and it is intended that a search for it will be made at a later date.

Bhotang mine.

The old mine at Bhotang is situated near the Gangtok-Siliguri road, about three-fourths of a mile on the Gangtok side of the village of Rangpo. Evidence of mining done by the ancients here was noted A considerable amount of development work had been carried out by Messrs. Burn & Co, who discontinued the work in 1918 or 1919.

The majority of the mine-openings are now inaccessible due to caving, but it was possible to enter one of the old stopes, and two samples from there gave 1·63 per cent. Cu. over 22 inches, and 4·85 per cent Cu. over 30 inches respectively.

Pachikhani

Evidence of extensive old workings is to be found on the hill side lying to the south of the village of Pakyong on the Pakyong-Rhenok pack road. There are two distinct sets of workings, the first lying about a mile above the village of Roruthang and the other some four miles further up the hill side to the north. Nearly all of these are now caved and inaccessible. A groove sample cut along one wall of an old trench at the upper workings gave all low values excepting one of 2 0 per cent. Cu. over 70 inches width.

It is proposed to extend, the investigation during the coming field-season to cover the western portion of Sikkim, and to re-open the lowest adit of the Bhotang Mine to allow for the sampling of the bottom section of that mine.

Messrs Martin, Burn & Co of Calcutta were asked for details of the considerable amount of work carried out in the area in the early part of this century by Messrs. Burn & Co. Since these have not been furnished it is assumed that the records have been lost. Attention is drawn to this in order to emphasise the necessity of including, in the new mining regulations now under consideration, a clause which will insist on records of work done, with plans, being lodged with Government prior to the abandonment of mining leases.

Copper deposits of Khetri.—During the months of October and November, a preliminary examination was made of the area of ancient copper workings in the Shekhawati district of north-western Jaipur State, lying between the villages of Singhana (28° 6′:75° 54′) in the north-east and Babai (27° 53′·75° 46′) in the south-west. Mr. Kerr-Cross was accompanied by Mr. R N. P. Arogyaswamy, Geologist.

These old workings are very extensive, and examination was made of those areas where the work had been most intensively carried out.

The Jaipur Mining Corporation Ltd (Messrs. Birla Bros.) hold a lease over the most important section, and carried out exploratory work there between 1944 and 1946, latterly under the supervision of an American engineer, Mr. Altshuler. This work consisted of driving a number of adits into the base of the western slope of the hill in the vicinity of the old Mandan (Madhan) mine, together with drilling several bore holes and mapping that section in detail. Inspection of this work led to the conclusion that the available data were insufficient to prove the ground.

The area is considered to be worthy of further exploration in depth, and it is strongly recommended that the work of Messrs. Birla Bros. be continued by extending one of the adits till it meets the ore-body. A thorough underground prospecting may then be carried out by driving and winzing, aided by diamond-drilling

Copper mines of Daribo.—The investigation of this area was carried out by Mr. Kerr-Cross accompanied by Mr. R. N. P. Arogyaswamy, Geologist during the month of November. The property appears to have been the most important of the many ancient workings, ruins of which are found in different parts of the area. It is at present leased to Daribo Copper Mines, but it is understood that the lease is to be abandoned owing to lack of funds,

Rajgarh district,
Alwar State.

Chalcopyrite and pyrrhotite are found somewhat sporadically disseminated in the slaty formation of the area. These have a general N. 20° E.--S. 20° W. strike and a steep westerly dip.

The ancients mined this sulphide ore from the outcrop in the hill side down to a depth of about 240 feet, and along the strike for a length of some 1,200 feet.

In 1870, an old incline had been driven in an effort to de-water the mine; but it was not until 1943 that the present owners managed to connect this tunnel with the ancient workings, and the process of de-watering was completed in 1946. The amount of useful development work carried out since has been negligible; besides general tidying up of the workings, two short tunnels have been driven at the southern end of the mine.

Further work in the form of winzing below the deepest horizon so far reached is considered worthwhile.

Shekhawati district, Jaipur State.

Old Damaotha Mine.—This is an ancient mine situated some three-fourths of a mile to the north-east of the village of Udepur (27° 44′: 75° 29′) in the Shekhawati district of Jaipur State. Mr. Kerr-Cross accompanied by Mr. R. N. P. Arogyaswami visited this area in October. It was the scene of considerable mining activity in ancient times, and old workings are traceable for a distance of some three-fourths of a mile along the western slope of a hill.

Judging from numerous specimens, the rock is for the most part a highly ferruginous quartz and felspar-breccia; and although traces of copper were found in several samples, no well-defined ore-body was seen.

Lying as it does some 20 miles to the south-west of the village of Babai in the Khetri area, it indicates the possible extension in that direction of the Khetri zone of mineralisation, and it is recommended that more detailed work should be done in the area lying between Udepur and Babai villages with the object of confirming this.

Shahabad district, Bihar.

Pyrites deposit of Amjor.—This deposit lies in the property of Messrs. Kuchwar Lime & Stone Co., in the Shahabad district of Bihar (24° 43′: 83° 59′). An examination was carried out in September to establish whether the deposit warrants development and if so to what extent. This was done in view of the request from Messrs. Kuchwar Industries & Fertilizers

Ltd., a new Company, for sanction to raise capital for the purpose of exploiting the deposit in connection with the manufacture of superphosphates.

The pyrites occurs in a dark shale cropping out near the base of a steep hill and can be traced for a distance of some 100 feet. The width varies from two and a half to three feet, and samples show a grade of 40 to 45 per cent. sulphur.

Although there are indications that the deposit is of considerable extent, further work is needed to confirm this. The exploration carried out by the owners, consisting of running two adits to 80 feet and 30 feet and drilling three boreholes, is considered quite insufficient to prove any appreciable tonnage of ore, and a further programme of exploratory aditing has been recommended for execution before sanction is given to the raising of the large capital sum in question.

SPECIAL MINERAL INVESTIGATIONS SECTION

COAL FOR SYNTHETIC PETROLEUM

To meet the ever-increasing requirements of fuel oil including aviation spirit, the Government of India have under consideration a scheme for the large-scale manufacture of synthetic petroleum from coal in the immediate future. For manufacturing one millon tons of synthetic oil, an annual supply of about seven million tons of coal, which could be cheaply and rapidly mined by open quarrying methods, would be required over a period of at least 30 years. The coal required would be of both caking and non-caking varieties of the second and third grades with ash content varying from 17 per cent. to 35 per cent., although it would be advantageous to fix the upper limit of the ash content of coals for this purpose at 25 per cent. Further, at the locality selected for the erection of the plant a supply of water of approximately 20 times the quantity of coal mined must be assured, while there must be adequate facilities for easy transport by road, rail or river.

The Geological Survey of India was entrusted with the task of locating seams complying with the above requirements and containing sufficient coal to produce one million tons of oil annually for at least 30 years. The area of investigation was confined to the major coalfields of Bengal and Bihar. A party of nine officers and a driller were deputed for the purpose. The party consisted of Mr. A. B. Dutt, Geologist (in charge), Mr. P. K. Ghosh, Geologist, Messrs. G. N. Dutt, K. D. Shukla,

K. S. Mahapatra, K. Balu and N. Venkatappaya, Assistant Geologists, Mr. Ch. Narasimha Rao, Technical Assistant, Mr. R. B. Ghosh, Assistant Chemist and Mr. N. Mariano, Driller.

Four coal-producing areas—East Raniganj, East and West Bokaro, Ramgarh and North and South Karanpura—were intensively examined. The results of the investigations are incorporated in a preliminary report which was submitted to the Government of India in September, 1948. The conclusions arrived at are that all the four areas are capable of providing quarriable coal of the type required.

In the Ondal area of the East Raniganj coalfield, and also in the combined East and West Bokaro fields, the entire quantity of 210 million tons required for a yearly production of one million tons over 30 years is available, assuming that an overburden up to thrice the thickness of the seams can be removed. If the removal of overburden of only twice the thickness of the seams is feasible, then the reserves in these two areas will be about 98 million tons and 144 million tons respectively.

In the Ramgarh field 58 million tons are available with an overburden up to thrice the thickness of the seams, and 40 million tons with an overburden up to twice the thickness. In the Karanpura fields within the portions examined the figures are 100 million tons and 68 million tons respectively.

The above estimates represent the minimum reserves, and more detailed exploration might well lead to an increase in the figures.

As regards the supply of water, there will be no difficulty at Ondal, as the Damodar river, controlled by the proposed projects of the Damodar Valley Corporation, will easily provide the quantity necessary. The other areas require further investigation in this respect.

According to Mr. Dutt, the establishment of a synthetic oil plant is an immediately practicable proposition in the Ondal area of the East Raniganj coalfield. It has also been suggested that a second plant might be erected in the vicinity of the Ramgarh and Karanpura coalfields, provided the requisite supply of water can be assured and transport facilities improved. Alternatively smaller plants might be erected in each of these three fields.

GOLD

Manbhum district, Bihar.

Messrs. K. K. Dutta and R. N. P. Arogyaswamy carried out a detailed investigation of the Gold Mines at Lowa (23° 1′: 86° 4½′), Manbhum district, Bihar. The property belongs to the Pathkum Estate and is situated near the village Lowa about four miles east of Parkidi railway station on the Chandil-Ranchi Section of the B. N. Railway. It has been under mining lease to the Lowa Gold Mines Ltd. for the last three or four decades. The mines comprise three separate workings which are confined to a narrow chain of hills stretching for about half a mile approximately E.–W. in direction, and are locally known as Balukkhad-East, Balukkhad-West and Tamapahar.

The country rocks of this area are micaceous phyllites and schists, with quartzites occurring in parallel bands, dipping south about 45°. The gold-bearing quartz vein, averaging about five to six feet in thickness, occurs between the quartzites and schists, the former forming the hanging wall. These workings are ancient, and the present lessees have developed them to some extent. The lode is ferruginous and a certain amount of copper is associated. The object of the investigation was to determine the quality of the ore, to estimate the available reserves, and to obtain an idea regarding the potentialities of the deposit. Work on the following lines was carried out:—

1. General geological reconnaissance.
2. Tacheometer and theodolite survey of the underground and surface regions.
3. Collection of representative samples:
   - (a) Bulk samples by blasting in workings and ends of workings.
   - (b) Groove samples at regular intervals in all accessible workings.
   - (c) By pitting from the tailings dumps.
4. Determination of alluvial gold.

The work was inspected by the Deputy Director (Mineral Development) and by Mr. Kerr-Cross, Mining Engineer.

The analyses of lode samples in the Geological Survey Laboratory show encouraging results. A detailed report of the investigations has been submitted.

GYPSUM

Cutch.

As the Salt Range, which formed the principal source of gypsum in undivided India, has been lost to the Indian Union since partition, the assessing of the quality and quantity of the various deposits of this mineral available within the Indian Union has assumed great importance. especially in view of the large anticipated demands for the manufacture of fertilizers at Sindri. With this object in view explorations were carried out in Cutch, Saurashtra (Kathiawar) and Sirmur (Himachal Pradesh) States early in 1948. Investigations of the gypsum occurrences in Cutch State carried out by Mr. C. G. K. Sastri revealed deposits occurring in formations of three different geological ages: (1) The gypsum deposits of Chitrod (23° 25′:70° 41′) and Badargarh (23° 24′: 70° 31′), which are associated with Jurassic shales, are hardly workable on an economic basis, since the deposits are either too poor or, when fairly rich, are small in textent. (2) Gypsum veins in Sub-nummulitic shales and marls occur in several places which include: (*a*) a fairly good deposit in the Rann, about 3½ miles east of Adesar (23° 33′:71° 1′ 15″), (*b*) the richest deposit in Cutch, east of the village Umarsar (23° 44′:68° 49′) and (*c*) a fairly rich deposit, ¾ of a square mile in extent, two miles west of Karanpur (23° 48′:68° 51′). There are other minor occurrences near Palanswa (23° 28′:70° 56′) and Matanomadh (23° 33′: 68° 57′). (3) Deposits of gypsum occurring in the creeks of Cutch are of considerable importance. Associated Cement Companies Ltd.. who have taken a lease over small areas encircling Bhojawali and Jaffarwali, have estimated the reserves at 90,000 tons.

The gross reserves of gypsum available from various deposits in Cutch are estimated at 2,071,000 tons. Although no single deposit in Cutch can meet the requirement of the Sindri factory, the Umarsar deposit with reserves of a million tons can be considered to be of commercial importance.

Saurashtra.

Mr. D. R. S. Mehta examined the gypsum deposits in Saurashtra, which occur as veins and segregations in a plastic clay horizon in the Gaj beds of the Tertiary formations of this area as well as in the ranns and recent formations. Gypsum occurrences in the Gaj beds, in Bhavanagar State, are small and hence not of much economic importance. West of Lunsapur (20° 55′:71° 25′) in the Jafrabad area selenite veins occur in the clays and the estimated reserve is about 14,000 tons. There are several deposits in Nawanagar State, the largest being that of the village of Ran (22° 10′:69° 20′) with an estimated reserve of 3,900,000 tons. This forms by far the most important deposit in Kathiawar. At Virpur (22° 15′:69° 20′) the deposits are similar to that of Ran; they occur in veins up to three inches in thickness. Estimated reserves are of the order of 490,000 tons. The deposits at Bhatia

(22° 6′:69° 17′) are estimated to have reserves of about 175,000 tons. There are three other minor occurrences: (1) about one mile north-east of Bhatia (22° 6′:69° 17′), (2) about one mile west of Nandana (22° 7′ 30″:69° 17′ 30″) and (3) about one mile west of Gurgat (22° 11′ 30″:69° 11′ 30″), with a total estimated quantity of 135,000 tons.

Among the deposits occurring in the Ranns and recent formations, gypsum occurs in Kuda (23° 10′:71° 23′) in Dhrangadhra State in bluish clay in a zone at a depth of 12-14 feet, noticed in brine wells of this area, but it is not of much economic importance. Gypsum occurrences noted near Kadiah (21° 1′: 71° 20′) in Junagarh State are of no significance. In Porbander State, gypsum occurs in a marsh (Rann) in the Meda creek, north-east of Miani (21° 49′:69° 26′), in a bed of yellowish clay under a thin covering of mud and silt (estimated reserve 11,000 tons). The source of the gypsum is the $CaSO_4$ in the highly saline and stagnant water, which converts the area into a marsh during the rainy season.

According to Mr. Mehta the occurrence of gypsum examined near Ran, in the Nawanagar State, is the most important in this area, and it can partly meet the requirements of the fertilizer factory.

Sirmur State, Himachal Pradesh.

Mr. Mukti Nath examined four deposits of gypsum in Sirmur State. The deposits, one mile south-west of Korga (30° 36′: 77° 35′) in the Nirikakhala gorge, occur in a steep and precipitous escarpment along the thrust zone between Jaunsars and Krol limestones and shales. The mineralised zone contains a mixture of anhydrite and gypsum associated with shales, limestone and dolomitic limestone, in the form of lenses, pockets and bands. From the nature of the occurrence it appears that the formation of gypsum has been brought about by sulphuric acid solutions reacting on the calcium carbonate constituent of the country rock. The degree and extent of the replacement of calcium carbonate by calcium sulphate have, however, been very variable. The mineralised zones of gypsum occur in the form of two main veins, striking east-west with a steep southerly dip. About 600 feet west of the northern vein, along the same strike, another gypsum bearing belt has been examined. A similar occurrence has been investigated about 700 feet west of the southern vein along the strike of the latter. Study of all these occurrences shows that, except in the northern vein where gypsum occurs in thick bands, in other places the mineral is highly contaminated and cannot be economically exploited. In the northern vein only the southern side of the western gorge of the Nirikakhala shows good gypsum, but even this zone contains lenses of dolomite and shale making the quality of gypsum variable. The estimated quantity of material with 60 per cent. gypsum is about 83,000 tons, and after sorting and handpicking it is expected that a quantity of 60,000 tons above 80 per cent. gypsum will be available. Transport of the material to the nearest rail head, however, is frought with great difficulty.

Deposits of gypsum also occur in the escarpment, about a mile north-north-west of Bharli (30° 33′:77° 45′). These are similar in their mode of occurrence to that at Korga. The mineral is contaminated for the greater part with dolomite. In the north-eastern part of the deposit there are bands of gypsum 10 to 15 feet thick with but little impurities; the south-western part of the deposit, however, shows gypsum of rather poor quality. By hand picking and sorting it is expected that about 300,000 tons of material containing above 80 per cent. gypsum may be available from this deposit.

Small deposits of gypsum of inferior quality occur about a mile south-west of Shilorna (30° 36′:77° 37′). The gypsum deposit of Ridana recorded by Dr. J. B. Auden[1] is small; but if the Bharli deposit proves to be of commercial importance this deposit can also be worked along with the latter, as it is only one furlong east of the Bharli deposit.

The three great obstacles in the way of commercial exploitation of the gypsum deposits of Sirmur State are: (i) the contamination of the gypsum with dolomitic limestone and shale, necessitating removal of an enormous amount of dead rock, (ii) the severe monsoon to which the lower ranges of the Himalayas are subject makes work impossible during that part of the year, and (iii) the distance from rail-head which makes transport very difficult.

RAW MATERIALS FOR GLASS AND CERAMICS

A survey of the raw materials required for the ceramic industries was begun in the Madras Presidency in 1945. It received an impetus in 1946 when the Council of Scientific and Industrial Research requested the Geological Survey of India to take up a comprehensive countrywide survey of the materials required both for glass and ceramics, and a separate party of officers was constituted within the Mineral Development Division under the general supervision of Mr. B. C. Gupta. The work is continuing, and several reports will shortly be published as monographs by the Council of Scientific and Industrial Research.

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[1] *Rec. Geol. Surv. Ind.*, LXVII, p. 382, (1934).

Clays

Mayurbhanj State, Orissa.

Mr. R. N. P. Arogyaswamy carried out a systematic examination of the China clay deposits near Karanjia (21° 45′ : 85° 58′) and Joshipur (21° 50′:86° 05′) in the Mayurbhanj State, Orissa.

The kaolin of these areas, according to Mr. Arogyaswamy, is primary in origin and is not the product of decomposition or weathering of the felspathic constituents in the granite or gneisses of the area. The mineral occurs in veins and lenses and is characterised by the scarcity of any palpable gritty material in it. The kaolin veins invariably persist at depth more than 40 feet from the surface.

Detailed prospecting was carried out in the Dumuria area (21° 50′:85° 59′), which is now under lease to Mr. S. S. Das of Baripada. More than one hundred trial pits, some of them going down to 15 feet were put down with a view to delineating the boundaries of the kaolinised zones. The available reserve of crude material in the Dumuria area has been estimated at 1,179,750 tons. For the purpose of the calculations it was assumed that only about 25 feet would be the depth to which the kaolin would be worked below the overburden which varies from 5 to 15 feet. It has also been assumed that the ratio of kaolin to waste is as 1:6.

In the Joshipur area the overburden is generally about 12-14 feet, but the clay appears to be more uniform in quality than that of the Dumuria area. The estimated reserve of the good quality material, free from gritty admixture, is 100,000 tons, and that of the grade II clay is 40,000 tons.

In the Chanchbani (21° 48′:86° 01′) deposit, situated about one furlong south of the village in the bed of a small *nala*, the available kaolin up to a depth of 25 feet has been calculated at 37,500 tons.

In the Kurma (21° 46′ : 86° 01′) deposit the available China clay (grade II) up to a depth of 25 feet has been estimated at 20,000 tons.

In the case of the China clay areas of Joshipur, Chanchbani and Kurma, Mr. Arogyaswamy is of the opinion that further detailed prospecting should be carried out by means of trial pits or borings with a clay auger, as most of these areas are under cover of alluvium or laterite.

Fire-clay, Bokaro coalfield, Hazaribagh district, Bihar.

Mr. D. R. S. Mehta carried out an investigation of the fire-clay deposits in the Bokaro coalfield. The area investigated comprises approximately the eastern half of the coalfield.

The fire-clays occur in the form of bands associated with coal seams, and include both refractory clays and shales. The colour of the fire-clay is usually black or grey and occasionally brownish. Specific gravity varies from 2·6 to 2·7. Only non-plastic fire-clays have been met with and they have to be blended with a bonding clay to make the refractory products.

Sixteen bulk samples of fire-clay collected from the eastern part of the Bokaro coalfield have been tested in the Geological Survey of India laboratory. Most of these do not fuse at 1350° C. and show linear shrinkage on firing, ranging between 2·5 and 22·5 per cent.

The total reserves based on a workable depth (below the surface) of 50 feet have been estimated at 5,315,000 tons.

Mr. G. G. K. Sastri carried out an investigation of the fire-clay deposits in the western part of the Bokaro coalfield lying approximately between the latitudes 23° 44′ and 23° 50′ and the longitudes 85° 0′ and 85° 55′.

The clay bands occurring in the Kargali and other seams of the Gumia (23° 48′:85° 50′) area and those associated with the coal seams in the Loiyo (23° 47′ 30″:85° 38′) and Mandu (23° 48′: 85° 28′) areas have been examined in detail and rough estimates of the reserves have been made of the fairly persistent fire-clay seams on the assumption that these can be economically worked up to a depth of 50 feet. The total reserves have been found to be approximately of the order of 445,000 tons in the area. Further, assuming that 12½ per cent. of the material has been already worked and thrown away, the available net reserves come to 389,000 tons approximately.

Fifteen samples of fire-clays, representative of the various seams in the area, have been tested in the Geological Survey of India laboratory. These invariably show poor plasticity and are infusible at 1350° C. Linear shrinkage on firing ranges between 7·5 and 25 per cent.

Fire-clays, Hoshangabad and Chhindwara districts, Central Provinces.

Mr. K. D. Shukla carried out a detailed survey of the fire-clays associated with the Upper Gondwanas of the northern slopes of the Satpura range in parts of the Hoshangabad and Chindwara districts of the Central Provinces.

Distribution.—Clay seams are found interbedded with white, soft, massive sandstones which are generally false-bedded and lie almost horizontally over most of the area. The clay is generally sandy and occurs in beds of three to six feet thickness.

Two seams of clay are found near the top of the northern slope of the plateau north of Talaia (22° 42′ 30″: 78° 43′ 30″). The upper seam is sandy and discontinuous but the lower seam is more fine grained and appears to continue for about a mile along the strike. Two seams of good quality clay, about six feet thick each, are found in the cliff-section about 1½ miles south of Kokripani (22° 41′: 78° 47′ 30″) and may be expected to be found over a large area.

Three to four beds of clay are found in the high ridges to the north of Hingpani (22° 43 : 78° 56′ 30″). The upper seams are found as small detached outcrops and the lower seams outcrop along the slopes. There is a bed of clay about six feet thick found about 1¼ miles north of Hingpani.

The area to the north and north-east of the Saonri village (22° 43′ 30″: 78° 59′ 30″) also shows a number of good seams. Three seams of clay, each about five to six feet thick, are found about two miles north-east of the village on the southern slope of the ridge which forms the edge of the plateau. The beds dip towards the south-east and the clay seams are found as outliers on the slope. Again, about two miles east of the village, three seams of good clay are found in the vicinity of the Hard river. To the south of Saonri a few seams of sandy clay are seen on the flanks of the ridges, but they require to be traced further along the strike.

In the southern part of the area within the Chhindwara district there are seams of clay found scattered all over the area. Generally, the clay seams are found on higher levels and the lower part of the Jabalpurs is mainly composed of sandstone.

Four seams of slightly sandy clay are found in the small ridge between Mandhi (22° 39′ 30″: 78° 51′ 30″) and Pando (22° 39′ 30″: 78° 51′ 30″). They are each about three to four feet thick and girdle the flanks of the ridge. Another five-foot thick seams of good quality clay is found at the foot of the hillock about a mile south-east of Mandhi on the path leading to Ghairi.

Two seams of fairly good quality clay are found near the surface in the vicinity of Chilak village (22° 38′: 78° 54′). About half a mile south-east of Chilak there are two thin seams of somewhat sandy clay seen on the slopes of the Singingarh hill (·3021). Another thicker seam of somewhat better quality clay is found below these seams and is exposed in the *nala* flowing north.

A seam of good clay, having a thickness of about five feet, is found at the bottom of the small hillock to the north-west of Rojhni village (22° 35′ 30″: 78° 58′). Another five-foot thick seam of clay in this area is found to the north of Banskhera village (22° 32′ 30″: 78° 54′ 30″).

About two furlongs south of Bhond (22° 37′: 78° 56′ 30″) there is a bed of sandy carbonaceous clay exposed along a small *nala*. Another seam of similar clay was found in the *nala* south-west of Pataghat (22° 35′ 30″: 78° 58′) and to the west of the Pindrai *nala*.

In the south-eastern part of the area, a three-foot thick seam of white compact clay is seen about half a mile north of Dhokhera (22° 37′ 30″: 78° 59′ 30″), and another seam of similar quality clay is found on the Daukhera-Khalla path about a mile north of Dhaukhera (22° 39′: 79° 1′ 30″). Again, a seam of fairly good quality clay is found about a mile north-north-east of Khalla on the path going to Kotra (22° 44′: 79° 3′ 30″).

Quality.—Most of the clays in the area are white in colour; they are generally somewhat sandy and at places slightly micaceous also, but a majority of them may be useful as refractory clays. The plasticity of most of the clays is poor to medium and only a few have been found to have high plasticity. Samples of clays from all the important seams in the area were tested in the laboratory of the Geological Survey of India for their refractoriness, and almost all of them were found to stand a temperature of at least 1200° C. without any sign of vitrification.

Quantity.—The clay seams in the area are generally three to six feet thick, and many of them appear to be lenticular. As it was not possible to trace the beds individually, an accurate estimate of the reserves cannot be made at this stage; but the number of seams found is very large, and a fairly large amount of clay may be expected to be available.

Although the general quality of the clay in this area is not particularly good, according to Mr. Shukla much of it will be quite suitable for the manufacture of ordinary fire-bricks, tiles, sanitary wares, pipes, etc., and quite a large number of workable seams of such clays are found in the area, especially in the vicinity of Hingpani and Saonri.

The area, being hilly and situated on the top of a plateau, suffers very much from lack of means of communication and proper approaches from the plains to the north of the plateau.

Detailed prospecting accompanied by boring and trenching should be done in areas where clay seams are found in larger number, *e.g.*, near Hingpani and Saonri, and the samples should also be practically tested for their suitability for the various refractory and ceramic industries.

White clays, Anantapur district, Madras.

Mr. R. Thiagarajan reports occurrences of small pockets of white clay in grey and brown slaty shales at Balapuram (57 F/13—14° 47′:77° 59′) in the Tadpatri *taluk* of the Anantapur district. On account of the extremely sporadic nature of the occurrences no estimate of the reserves could be made. Mr. Thiagarajan also visited Uravakonda (57 F/1—14° 57′:77° 16′) in the Gooty *taluk* and Palovi (57 F/2—14° 31′:77° 10′) in the Kalyandrug *taluk* of the district, in connection with the investigation of a reported occurrence of ceramic raw materials. But no exploitable clay deposits could be found in these localities.

Clay, Bellary district, Madras.

The following villages in the Bellary district were visited by Mr. R. Thiagarajan in connection with the investigation of ceramic raw materials which were reported to exist there:

1. Hathi (there is no such village as reported in the Bellary *taluk*), 2. Papinayakkanahath (57 A/8—15° 15′:76° 29′), Hospet *taluk*, 3. Harpanahath (48 N/13—14° 47′:75° 59′), Harpanahalli *taluk*.

The search for workable clay deposits proved unavailing in all the places.

Mr. A. P. Subramaniam has examined several clay deposits in the East Godavari district:

White and coloured clays, East Godavari district, Madras.

(1) Kottabommur (16° 58′:81° 48′)—White clays are noticed in two small hillocks south-west and south of the above village, intercalated with red grits and sandstones. Fairly good clay devoid of iron stains occurs about 20 feet below the grits and a layer of mottled clay. Clay has been won for some time past from the south-east face of the western hillock. As there appears to be a persistent horizon of

bluish clays below the grits, in the surrounding area, quarrying at the base of the hillock is likely to yield a few thousand tons of good clay.

(2) Razole (16° 57′:81° 49′).—In hillock ·207 E.N.E. of Razole bluish clays are encountered at the base, below the grits and sandstones. Small balls of bluish clay are noticed in the gullies all round.

(3) Punyakshetram (16° 59′:81° 51′).—Clays have been won during the last thirty years or more from a horizon thirty to forty feet below the surface, in the neighbourhood of the above village. The clay which is intercalated with sandstones and grits occurs at a depth of 25 to 30 feet and is reported to form a 10 feet thick layer. As the water table in the area is about 90 feet below the surface, extraction of these clays will not present any difficulty. The reserves of good clay in the area will be of the order of two lakhs of tons for the first 30 feet of excavation. The clay is of a greyish white plastic variety, both laminated and compact types being available.

(4) Indications of clay are noticed at Dhowlaishwaram (16° 57′:81° 47′) and Burgupudi (17° 7′ 30″:81° 50′).

(5) Peddapuram (17° 5′:82° 8′ 30″).—In the southern, northern and eastern slopes of hillock ·250 west of Peddapuram, white and bluish white clays are exposed about 15 feet below the Rajahmundry grits. The clay varies from a finely laminated shale to hard compact lumps and forms a 10-foot thick bed below the sandstones. The reserves in the area are likely to be of the order of nearly 10,000 tons for the first 20 feet.

(6) Jaggampetta (17° 10′:82° 4′).—About a mile and a half W.N.W. of the above village, along the Gokavaram road, white clayey sandstones are noticed, and this material is well exposed in a stone quarry a mile south of ·471, below the laterites. Another quarry about half a mile south of Gurapalem (17° 12′ 30″:82° 4′) exposes excellent white clay rock, below the sandstones. This appears to be a highly kaolinised khondalite. Similar material is stated to have been encountered in a number of quarries all around. The clay which is noted to extend to a depth of more than 20 feet is likely to yield about 20 per cent. of white kaolin on washing. The reserves are fairly large and the deposit is close to lines of easy transport.

Coloured clay, West Godavari district, Madras.

Mr. A. P. Subramaniam has examined the Upper Gondwana clays at Dwarka Tirumala (16° 57′:81° 16′). The clay is greyish white and highly plastic and varies from a laminated shale to hard compact lumps. The fine clay here is being won at a depth of 20 feet below the sandstones, though outcrops of shale are noticed at many points. Good plastic clays occur as a six-foot thick layer intercalated with laminated shales. The reserves in the area are very large and likely to be over a million tons for the first 25 feet from the surface downwards. The slopes and margins of the hill ·490 and ·428 can be profitably exploited. Besides the clay, an abundant quantity of red iron-stone shale suitable for the manufacture of pigments is available forming a thin bed over the clayey shales. The clay deposits are close to lines of transport and only ten miles north of Bhimadol Railway Station. Representative samples of all the varieties of clay noticed have been collected for laboratory tests.

White clay, Kurnool district, Madras.

Mr. R. Thiagarajan records a deposit of chalky clay about 1½ miles east of the village Kochcheruvu (57 E/15—77° 52′: 15° 19′ 15″), Dhone *taluk*, Kurnool district, just inside the Madhavaram Reserved Forest. The deposit extends in a N.N.E.-S.S.W. direction over an area about 200 feet by 150 feet. The working pit situated at the south-west corner of the deposit is eight feet deep and there are indications that the deposit might extend deeper down.

A similar deposit of chalky clay has been recorded about half a mile south-west of the village Malkapuram (57 E/15—77° 59′:15° 20′ 45″) in Dhone *taluk*. The occurrence is in Vempalle limestones dipping southward and lying between two trap sills. The exposure is one furlong long along the flanks and the thickness from a few feet to about 10 to 12 feet. It is quite likely that the deposit might extend in the direction of dip and strike.

Glass Sands

Burdwan district, West Bengal.

Mr. R. N. P. Arogyaswamy examined the friable quartzites in the vicinity of Taldanga (23° 46′ 30″:87° 06′ 00″) about 1½ miles east-south-east of the Churulia Station, E. I. Rly., in the Burdwan district of West Bengal.

These quartzites are seen to crop out in the village itself and appear to continue for about 1,000 feet to the west. The dips are fairly low—between 5° to 12° to the N.N.E. In general appearance the formation strongly resembles finely bedded sandstones.

The rock is highly silicious and friable for about 1,000 feet from the western end of Taldanga, and this constitutes the best part. The western outcrops of the rock are either rich in ferromagnesian minerals or are silicified, hard and massive.

The available reserve of the dressed and sorted material in the occurrence has been estimated at 30,000 tons.

Mr. Arogyaswamy also examined the coarse grained Barakar sandstone of the Dabor area (23° 48′:86° 55′), about 2½ miles south-east of the Rupnarayanpur Station of the E. I. Rly.

Although there is no special property noted in these sandstones that could make them particularly suitable for use either as moulding sands or as glass sands, glass had been manufactured in the past from these sandstones with success, and there is yet an old glass factory on the Dabor Colliery premises.

The reserve has been estimated at 5,500 tons.

Manbhum district.

Mr. R. N. P. Arogyaswamy examined the friable sandstone bands occurring in the lower portion of of the Barakars in the Itapore area (23° 47′ 30″:86° 59′ 00″), Manbhum district, Bihar.

The rock is typically false-bedded, generally coarse grained and of various shades of colour ranging between dull grey and orange. This formation has a general southerly dip of 10° to 20°. The area does not appear to be very promising, as the sandstones are rather coarse grained and clayey, and they are also banded, so that working them may be a difficult proposition—with consequent high losses in dressing, sorting, etc. There is no other particular characteristic, that makes these rocks superior in quality to other light coloured Barakar sandstones, than their friability.

The reserves on the assumption of a workable depth of 20 feet have been estimated at 700 tons.

Banda district, United Provinces and Rewa State, Central India.

Mr. D. R. S. Mehta carried out an investigation of glass-making sands in parts of the Banda district, United Provinces and Rewa State, Central India. The occurrence of glass sands along the G. I. P. Railway from Lohgarh to Bargarh in the Allahabad and Banda districts, popularly known as the Naini area of glass sands, is already well known. The present survey was undertaken with a view to investigating the extension of the Naini deposits further to the west and south-west.

The area under investigation consists almost entirely of Dhandrauli quartzite, the topmost horizon of the Kaimur series of the Vindhyan system. The general dip of the rock is 2° to 5° south-east. The quartzite is massive and fine grained, the grain-size being approximately 0·5 mm. The colour in hand specimen varies from pure white to purple, the former being predominant.

Generally speaking, the quartzite occurring south of the G. I. P. Railway from Markundi (25° 1′:80° 57′) to Panhai (25° 5′:81° 13′) is fine grained and flaggy, with iron oxide streaks at very short intervals. Apart from the difficulty of removing the iron-oxide, the sand obtained from this area is fine grained and does not appear to be suitable for glass manufacture. Glass-sand patches have been frequently met with throughout the rest of the area investigated. They are comparatively small and sporadic north of the railway line from Markundi to Manikpur (25° 3′:81° 6′); but a continuous zone develops further to the east, expanding steadily in width, till it assumes an enormous size near Panhai. The area around Panhai and Dabhaura (25° 17′:81° 18′) and for some distance further to the east is a more or less continuous patch of friable quartzite and is undoubtedly of very great economic importance. The eastern extremity of the area under investigation near Suti (25° 8′: 81° 4′ 30″) shows only sporadic patches, while the agricultural land south of the same is almost completely devoid of glass making sands.

The very nature of the glass sand deposits makes it difficult to ascertain accurately the area occupied by individual patches or to determine the thickness of the friable zone without putting in a very large number of pits in each case. An attempt, however, has been made by Mr. Mehta to demarcate the friable zones on the map and also to calculate the reserves of sand in the area under investigation. The calculations which do not take into account the quality of the sand, serve the purpose of a rough guide only.

Thirty-eight representative samples of sand collected from the area have been analysed in the Geological Survey of India laboratory. In almost all the samples the bulk of the sand is not coarser than 30 or finer than 100 mesh—thus the grain size is suitable for the manufacture of glass. The Fe_2O_3 content in every case is above 0·1 per cent., rather too high for optical and best crystal glass. It is, however, within the permissible limit of 0·2 per cent. for plate-glass in the majority of samples, while almost all the samples are suitable for the manufacture of window-glass, white bottles, etc.

The aggregate area covered by the friable quartzite patches is about 2,951,207,424 square feet or 105 86 square miles. Allowing 25 per cent. for sporadic small patches of hard quartzite in the main zones the actual area of friable quartzite is roughly estimated to be 2 213,405,568 square feet.

On the assumption of one foot average thickness of the friable quartzite throughout the area, the gross reserves of glass sand are 2,213,405,568 cubic feet; and taking 20 cubic feet of glass-sand to weigh one ton, the gross reserves in the area come up to 110,670,278 tons.

Quartz and Felspar

Mr. D. R. S. Mehta carried out an investigation of the quartz and felspar deposits in the Kodarma area, Hazaribagh district, Bihar. The investigation formed a part of the general survey of ceramic raw materials in India. The minerals occur mostly in the pegmatite veins mined on a large scale for mica.

The following mines were visited in the course of the investigation:—

I. *Kari Mine* (Messrs. Gangadhar Samanto & Co.). - About one mile north of Kodarma Inspection Bungalow. The debris thrown out from the mines does not exceed 10 tons daily. Only small quantities of quartz and felspar can be collected from such a small mine.

II. *Phalguni Mine* (Messrs. Chatturam Horilram, Ltd). - One of the biggest mines in the Kodarma field, located about six miles north-east of Meghatari Forest Rest House. On the average 25 tons of debris are thrown out daily, of which approximately 50 per cent. is quartz and 10 per cent. felspar. The reserves of quartz and felspar in the dumps of this area are of the order of 6,250 and 1,250 tons respectively.

III. *Belwa Mine* (Messrs. Chatturam Horilram Ltd.).—Situated about three miles north-east of Phalguni Mine. The daily output of debris is three to four tons, of which quartz and felspar from 25 per cent. and 10 per cent. respectively. Reserves available in the dumps are 781 tons quartz and 312 tons of felspar.

IV. *Banderchua Mine* (Messrs. C. M. I. Ltd.).—Situated about six miles south of the Meghatari Rest House. The pegmatite here consists almost wholly of a graphic intergrowth of quartz and felspar—practically inseparable.

V. *Mejhli Mine* (Messrs. S. K. Sahana Ltd.).—Situated about four miles north-east of Kodarma Forest Rest House. About 20 tons of debris are thrown out of the mine every day. The percentage of quartz and felspar in this is 50 and 25 respectively.

Samples of felspar from the five selected mica mines mentioned above have been analysed in the Geological Survey of India Laboratory with the following results:—

——	I. Kari.	II. Phalguni.	III. Belwa.	IV. Banderchua.	V. Mejhli.
SiO_2 . .	67·90	64·54	66·28	64·40	63·22
Al_2O_3 . .	21·10	22·01	21·02	22·21	20·51
Fe_2O_3 . .	0·40	0·99	0·98	0·79	0·79
MgO . .	0·65	0·47	0·51	0·76	0·82
CaO . .	1·67	2·64	1·67	2·30	0·12
Na_2O . .	7·69	8·73	8·80	8·46	2·75
K_2O . .	0·42	0·51	0·50	0·70	10·80
Loss . .	0·30	0·10	0·20	0·18	0·20
TOTAL .	100·13	99·99	99·96	99·80	99·51

V. ENGINEERING GEOLOGY AND GROUNDWATER INVESTIGATIONS

MAJOR PROJECTS

DAMODAR VALLEY PROJECT

Panchet dam-site, Manbhum district, Bihar.

Messrs. P. C. D. Hazra and K. K. Dutta investigated the Panchet dam-site, Damodar river, Manbhum district, Bihar in January, 1948. This project which is a part of the Damodar Valley development scheme envisages a 130-foot high earthen dam from the present river bed at approximately 23° 40′ 42″:86° 45′ 52″ about three miles above its junction with the Barakar river. The dam-site area lies at the western edge of the Raniganj coalfield. The river here has a flat channel with gently rising banks continuing for considerable distance each way, due to which the embankments will have to be very long, nearly 8,870 feet.

Along the alignment proposed by the Central Technical Power Board, the left abutment of the dam would be wholly on the Archaean quartzites and schists, which are found to be satisfactory for the foundation purpose, but the right abutment would first intersect a fault and then pass over the Barakars. Moreover, this fault, with a prominent crush zone, runs quite close to the upstream side of the proposed dam for a considerable distance, and as such might cause appreciable leakage. Though the arenaceous phases of the Barakars are considered to be sound enough as dam foundation, some thin interlaminated bands of shale and coal are viewed with uncertainty. Entire elimination of the fault plane as well as the Barakars could be achieved either by shifting the axis upstream half a mile or by deflecting the alignment considerably. Tentative recommendation has been made for shifting the axis 400 yards slightly upstream, in order to minimise the effect of the fault. Before any decision regarding the shifting of the axis is made, the fault plane should be explored by pits and trenches along its entire length.

Several test pits were made by the field-staff of the Central Technical Power Board for borrow materials, but they do not appear to have been properly located and sampled. The borrow areas should preferably be on the upstream side of the dam. The soil from Banda (23° 41′:86° 45′ 20″) and Maheshnadi (23° 40′: 86° 45′) appears suitable and should be tested. For sampling, the test pits should be carried down to the top of bed-rock, and representative samples from various types of materials should be analysed, as otherwise summation curves based on the analyses of surface samples would give a wrong idea about the true character of the soil.

Messrs. Hazra and Dutta conclude that further geological work should be directed to determine the sources and reserves of other materials of construction, *e.g.*, gravels, rocks for rip-rap, etc., hitherto not investigated, and recommend that prior to the commencement of the proper foundation exploration by drilling, trenching, etc., it is imperative that all geological features should be mapped on a large scale plan, say 16″=1 mile.

Balpahari dam-site, Barakar river, Manbhum district, Bihar.

At the instance of the Damodar Valley Corporation Mr. P. C. D. Hazra was deputed in January, 1948, to carry out a preliminary investigation of the Balpahari dam-site with a view to ascertain the suitability of the site tentatively proposed by the Central Technical Power Board and to put up suggestions for further detailed work. The dam-site is located on the Barakar river at 24° 2′ 37″:86° 23′ 35″, sheet 72 L/8. A rock-fill dam with rolled earth core and about 115 feet in height is envisaged.

The area comprises a part of a Lower Gondwana outlier surrounded by the Archaeans. The outcrops of the younger formations are found in the river section where the dam would rest on the Talchir Boulder bed (with sandstones) and Barakars, represented by massive to thin-bedded sandstones of variegated colour. Due to the excessive crest length, the abutments would extend over the metamorphics represented principally by granites and granite-gneiss. At the dam-site the sedimentaries dip S.S.W. (obliquely downstream) at low angles 12°-18°, but variations of dip and strike are noticeable both upstream and downstream. About two furlongs downstream a flat synclinal structure is seen north of Charakh Kalan (24° 1′ 30″:86° 24′ 30″).

From his preliminary survey Mr. Hazra concludes that foundation conditions for the proposed dam appear quite satisfactory and that rocks are strong enough to support a dam of the contemplated height. The rocks in the river channel are reasonably fresh and only a small amount of stripping would be necessary to reach foundation grade. Although the downstream component of the dip is unfavourable from the point of view of stability and leakage, he thinks that this drawback can be easily overcome by a suitable design (flattening of slopes, etc.) and by provision of an adequate cut-off, which would eliminate chances of sliding and leakage.

An alternative site with an upstream dip was also located about one mile upstream of the present site, but further geological investigation, including mapping on a large scale, 16″=1 mile or 1″=100′, is essential before a definite opinion can be given with regard to its merit.

No dearth of materials for construction within short-haul distance is anticipated. The harder varieties of Talchir and Barakar sandstones would probably be satisfactory for rock-fill. rip-rap or aggregate after crushing. In the event of their proving otherwise on tests, the metamorphic rocks from adjacent areas should be explored.

No test pits for borrow material have yet been put down. Mr. Hazra recommends that this work should be undertaken during further investigation of the dam-site. He emphasizes that representative samples from the test pits, carried down to the top of the bed-rock, should be collected for analyses in a soil mechanics laboratory, as the results yielded by samples taken from top layers only give totally wrong information regarding the character and quantity of materials available. The soil from Palkia (24° 4′:86° 23′) appears suitable for the earth-fill core of the dam and should be first tested. Finally, Mr. Hazra recommends that a few shallow bore-holes should be drilled in the river bed to obtain necessary sub-surface data which could be used in deciding the nature of cut-off and the extent of stripping to reach foundation grade.

Konar Project.

At the instance of the Damodar Valley Corporation, Mr. K. K. Dutta carried out a detailed geological investigation of the dam-sites and appurtenant works for the Konar Project in February, 1948. The Konar Project, which forms a part of the Damodar Valley development scheme, envisages building three dams and power houses and other construction works on the river Konar and its feeder the Boro *nala* in the Hazaribagh district, Bihar (73 E/3). The main dam will be on the river Konar, near the village Tilaiya (Grid 580:300; 73 E/3). The water of the reservoir will be led by a canal, pressure tunnel and penstocks into turbines located on the bed of the Boro *nala* (Grid 326:595). There will be two more dams and power houses on the Boro *nala*. The second dam will be at grid 356:550, feeding into penstocks for a power house at grid 358:547. The No. 3 Dam and Power house will be at grid 372:473 and 370:471. The site for the dam on the Konar river was previously investigated by Mr. P. C. D. Hazra in 1946.

The area forms a part of the Hazaribagh plateau. The surrounding country is a soil covered, rolling plain. The channel of the Konar is flat, shallow and meandering, quite in keeping with the surrounding pene-planed surface. But the Boro *nala* which flows only two to three miles east of the Konar forms a steep sided valley with a remarkably straight course for a long distance. No fault has been located along this straight course, but exploration alone will prove if one is present and if any serious weak zones occur.

The rocks of the area belong to the Archaean complex, here represented mainly by granite-gneisses associated with minor occurrences of amphibolite, quartzites, marbles, etc. All the rocks are extensively intruded by pegmatites.

After selecting suitable sites for the dams and power houses, sub-surface exploration by boring and trial pits has been recommended. For the Konar No. 1 dam-site, eleven boreholes (vertical), six on the river bed and five on the abutments, have been recommended, each hole 100 feet deep. Besides, a number of trial pits have been suggested along the dam axis. Two vertical and one angle hole have been suggested for Konar Nos. 2 and 3 sites. Trial pits would also be necessary along each of these axes.

For the dam on the Konar river a rock-fill dam was originally planned; but due to lack of suitable rock-fill material Mr. Dutta recommended an earthen dam. Suitable areas for borrow materials were demarcated and a programme of exploration for soil by trial pits has been recommended.

The preparation of a 6″=1 mile map to cover the whole area around the projects is recommended. Survey maps on 100 feet=1 inch should be prepared of the different areas of the proposed dams, power houses, building sites, canal alignments, pipe lines and borrow areas.

Tilaiya dam-site, Hazaribagh district, Bihar.

Messrs. P. C. D. Hazra and K. K. Datta investigated the Tilaiya dam-site (72 H/11; 24° 19′ 30″ : 85° 32′) on the Barakar river in March, 1948. The dam-site is eight miles from Kodarma railway station on the East Indian Railway. The project, which forms a part of the Damodar Valley development scheme envisages a 90-foot high (from the present river-bed) sand and gravel structure. The dam-site and the reservoir area was previously examined by Mr. M. S. Balasundaram[1] in 1947.

The dam will close up the gap formed by the Barakar river across a ridge consisting of vertically dipping bands of quartzites and mica-schists. The ridge is flanked on the north by a soil covered plain consisting of quartzites and granitic gneiss and on the south by a plain underlain by grey, silky garnetiferous mica-schist.

Foundation conditions.

Since the bands of quartzites and mica-schists in the ridge are narrower than the base width of the dam, a few bands of both the types will come under the foundation. The rocks are generally strong enough for withstanding the load of a concrete structure of the contemplated height, though in the case of the mica-schists deeper excavation and some amount of grouting may be necessary.

The originally proposed axis of the dam corresponds with the axis of the ridge, but an alternative alignment about 110 feet upstream has been suggested. In the latter case some portion of the ridge would be left on the downstream side to act as a buttress for the dam and a thick quartzite band would come under the upstream toe of the dam, which would also act as a cut-off wall.

Some amount of exploratory work at the dam-site, mainly on the right abutment, was carried out by the military engineers during the last war under the auspices of the Central Technical Power Board. Nothing is known about the sub-surface condition of the left abutment. Again, the information regarding the geology under the river bed is also incomplete. Therefore, a fresh drilling programme with special reference to left abutment was outlined to find out the exact nature of the quartzites and the mica-schists at depth. A few trenches on the left abutment have also been recommended.

As a result of their investigation Messrs. Hazra and Dutta conclude that a concrete dam would be better suited for the site than the earthen dam originally proposed by Central Technical Power Board. The resources of natural aggregates are limited in the area, but quartzites from the ridge can be crushed for the purpose. Sufficient quantities of sand will be available from the river bed. Cement will have to be brought from Dehri-on-Sone, 100 miles away. As the areas removed from the major earthquake zone of North Bihar, provision of a safety factor of 5 per cent. is considered satisfactory.

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[1] *Rec. Geol. Surv. Ind.*, 81, Pt. 1, p. 72 (1949).

Bore-hole sites on the left abutment.

In compliance with a request from Mr. R. J. Mattson, Damodar Valley Corporation, Mr. P. C. D. Hazra visited the Tilaiya dam-site, Barakar river, (72 H/11; 24° 19′ 30″: 85° 32′), in June, 1948, to locate suitable positions for boreholes on the left abutment of the proposed dam. Due to the imminent approach of the monsoon only two holes which would yield maximum information for design purposes within a short time were proposed by the Damodar Valley Corporation. As two principal rock types are represented in the area, *viz.*, quartzite and quartz-mica-schist, Mr. Hazra recommended that each rock type be explored by a borehole up to 100 feet in depth from surface. Assuming the dam-axis at "B" one hole was located near the projected upstream face of the dam on the quartzites whilst the other was located about 100 feet downstream on the mica-schists near the approximate downstream toe of the dam.

Submergence of minerals of economic value.

Mr. G. C. Chaterji investigated the possibility of the submergence of a deposit of China-clay near Tundi (23° 59′: 86° 28′) in the Deolbari reservoir area, and of some reported Damodar (Damuda) coal measures formations in the Maithon reservoir area in December, 1947.

China clay, Deolbari reservoir area.

A deposit of China clay occurs on the Sarbapahar (hill No. 1108) south-east of Tundi (73 I/5; 23° 59′: 86° 27′). It is at above the 1,000-foot contour level according to the 1 inch=1 mile Survey of India topographical map of the area. The outcrop occurs about 300 feet above the level of the Deolbari reservoir (Preliminary Memorandum on the Unified Developments of the Damodar Valley, August, 1945, Central Technical Power Board, 1946, Exhibit 11).

The hill is steep and densely covered with thorny scrub and creepers. Geologically the hill is made of scoriaceous and brecciated fault quartz vein with angular cavities faced inside by druses of quartz crystals. The kaolin deposit is in the form of a vein with irregular outlines. It is two to three feet thick and can be traced along the strike (N.W.–S.E.) for 24 feet. It dips at a steep angle into the hill and appears to extend in depth. The clay is gritty but white with slight ferruginous staining here and there. The vein has been worked intermittently by the local villagers. The working covers a length of 17 feet and has reached a depth of three to four feet. The material is used for whitewashing mud huts. It is reported that on washing about 50 per cent. goes out as sand.

The Balpahari dam-site is several miles upstream of Tundi. Thus there is no likelihood of the China clay deposit being drowned by either the Deolbari or the Balpahari reservoir.

Damodar coal measures, Maithon reservoir area.

Twelve small outcrops covering in all about 0·75 square miles, which, on the basis of an unsigned and old geological map, were considered as belonging to the Damodar coal measures sequence, occur in the submerged area of the Maithon dam. These are located near Damdaha (23° 50′: 86° 52′), Kushiara (23° 53′:86° 50′), Saharaj (23° 49′:86° 50′), Shampur (23° 53′:86° 46′), Nitaidih (23° 54′:86° 46′) and Panjania (23° 53′:86° 45′) in sheet 73 I/13 and near Chalna (23° 55′:86° 42′) in sheet No. 73 I/9.

All these areas were visited and the rock outcrops in and around these areas were carefully traced by Mr. Chaterji. No sedimentary rocks were found in these areas. What superficially simulate Barakar sandstone and arkosic grit are in reality weathered bands of micaceous gneiss and quartz-granulite belonging to the Archaean metamorphic series, and possessing low foliation dips. The existence of pegmatitic and quartzose veins in them and their overall field relations with the adjoining outcrops of hornblendic and felspathic gneisses leave no doubt about their metamorphic nature. Thus there is no possibility of any coal deposit being drowned in such areas.

GODAVARI VALLEY PROJECT

Mr. V. Subramanyam made a preliminary study of the Ramapadasagar dam-site on the Godavari river early in December, 1947 and a detailed investigation of the project in May 1948.

Ramapadasagar dam-site, Godavari river, near Polavaram, West Godavari district.

The Project envisages a dam across the Godavari river, twenty miles upstream from Rajahmundry (65 G/16; 17° 0′:81° 46′ 30″). It is a multipurpose project. The sanskritic name of the project has been derived from the fact that the waters of the proposed reservoir will back up and rise so as to touch the feet of Sri Rama at Bhadrachalal (Bhadrachalam temple) 100 miles upstream of Rajahmundry. (*Rama*: an incarnation of *Vishnu*; *pada*: feet; *sagar*: ocean. An ocean lapping the feet of Sri Rama.)

The site for the proposed dam lies 1¼ miles north of the village of Polavaram (65 G/11; 17° 15′:81° 38′ 45″), and the alignment of the dam, 6,600 feet long, runs eastward from Gummadi Konda on the west bank to Mahanandiswara hillock in the middle of the river, and then strikes S.55° E. and ends in the spur north-west of Vara Konda, about one mile north of Purushottapatnam (65 G/11; 15° 15′:81° 40′) on the east bank of the river. Excepting the abutment hills and the central hillock, which expose hard gneissic rocks, the rest of the river bed and adjoining flood plains are overlain by thick beds of sand and clays. The depth to bed-rock as determined by calyx drills and penetrometer is variable. The deepest level from which the foundation is expected to start is about minus 200 feet and the height of the dam will be 428 feet from the foundation. The foundation problem of this dam will be one of great difficulty, the like of which has not hitherto been attempted elsewhere.

The Board of Consulting Engineers for the dam have unanimously approved, on the strength of the experiments conducted so far, that the site selected is the best possible site and that a concrete gravity dam can be constructed on rock foundation, despite the unusual river diversion and deep foundation excavations. They have also suggested the use of cellular coffer dams of steel sheet piles and excavation of foundations and laying of concrete in the open.

Geology.

The rocks of the dam-site area belong to the Khondalite suite, chiefly garnet-sillimanite-gneisses, garnetiferous-gneisses and granulites, calc-gneisses, calc-granulites and quartzites. Associated with these and also intrusive into them are bands of charnockite. Interbanded with the gneissic rocks of the area are also bands of gneissose granites. Intrusive into all these rocks are pegmatites and quartz veins. The gneissic rocks and granulites have a general regional strike of N. 60°–80° E.–S. 60°-80° W. and a dip of about 70°-80° to the north or south.

Faults, joints and other structural features.

No faults or shear zones have been observed in the rock mentioned above. Minor anticlinal or synclinal folds have been observed south of Gummadi Konda on the west bank. Two sets of major joints have been observed in the rocks—one set running roughly N.–S. or N. 15° W.–S. 15° E. and dipping vertically, and another set at right angles to it. These joints are reasonably tight and are not generally expected to continue in depth.

Study of bore-hole cores.

Mr. Subramanyam studied cores from bore-holes put down along the axis of the dam and for a distance of 200 feet to the north and south of it. The cores are all chiefly garnetiferous gneisses with some associated charnockites. He finds that some of the bore-holes have touched bed-rock or have been taken only a few feet into it, and that some others have been taken only up to the zone of weathered rock. Examination of the cores leads one to doubt whether some of them may not be from boulders rather than from the bed-rock. This is especially the case with some of the cores from the deep bore-holes put down on the western side of the river. In order to clear all doubts, Mr. Subramanyam has suggested some more borings in the river-beds, to go down at least 50 feet into sound fresh rock.

Suitability of the dam-site.

Mr. Subramanyam is of the opinion that the site selected is geologically suitable for a dam of the desired height.

Right and left canal tunnels.

It is proposed to take off one canal from the right and one from the left side of the reservoir. On the right side, it is desired to have a pressure tunnel through the saddle N.N.E. of Tutigunta (65 G/11; 17° 15′ 30″: 81° 37′ 30″). The tunnel will be across the strike of the gneissic rocks and associated charnockites, which dip steeply towards the south. The tunnel will be half a mile long. No folds or faults have been observed in the tunnel area. Mr. Subramanyam finds that tunnelling is feasible and lining the entire tunnel may not be necessary. He has suggested that the charnockites south of the tunnel area can be used as material for coarse aggregate for lining the tunnel.

On the east bank, it is proposed to construct a tunnel, about two furlongs long, in the saddle east of Vara Konda from near R.L. plus 160. The rocks of the tunnel site are chiefly garnetiferous gneisses of the Khondalite suite, dipping steeply south. Tunnelling is feasible and the tunnel will be at right angles to the strike of the rocks. There are no folds or faults in the tunnel area. Joints observed are reasonably tight.

Lock saddle.

It is proposed to have an open cut and a system of locks in the saddle west of Vara Konda on the east bank of the Godavari river. The rocks of the area are chiefly khondalites and charnockites. Some of the charnockites from here can be used as material for aggregate during the construction of the left side of the dam.

Building materials.

Mr. Subramanyam reports that cement will have to be imported as there are no good resources of cement making limestones in the vicinity of the dam-site. As regards materials for coarse aggregate, there is no dearth of this and enough can be obtained within a radius of three miles from the dam-site. For fine aggregate, the Godavari sand can be used, but this may require washing before use.

KOSI PROJECT, NEPAL

Mr. K. K. Dutta visited the Kosi dam-site in February, 1948. This visit coincided with that of Dr. Savage, American Consulting Engineer, who had also been brought to examine the foundation conditions.

This project under the Central Waterpower, Irrigation and Navigation Commission envisages a 700-foot high dam (above the present river level) on the Kosi river near Barahakshetra (26° 53′ : 87° 11′), Nepal. Geological investigation of the dam-site had started and bore holes had been recommended by the Geological Survey of India in the beginning of 1947.

At the time of Mr. Dutta's visit boring had not started, but a total of 3,000 feet of tunnelling had been done in 26 tunnels. The tunnels are distributed on either abutment covering the foundation area of the proposed dam. Nine of these tunnels have exceeded 150 feet, while three have gone beyond 200 feet.

Mr. Dutta carried out detailed mapping of the abutments on 32″=1 mile scale, and logged the different geological features within the tunnels.

From a study of the tunnels it was found that in addition to the upper weathered zone, the quartzites abound in shattered and sheared zones, which also have to be removed by excavation in order to ensure the foundation of the dam on fresh and strong rock. Again, both from the abutments and the tunnels, it was found that the quartzites are associated with thick bands of slate which persist in depth. These slate bands being weak zones will have to be excavated to greater depths than the quartzites. Since most of the tunnels had not reached sound rock, no idea regarding the amount of excavation necessary could be given, but from the features met with inside the tunnels, it was assumed that excavation would exceed 150 feet at places. To find the depth of excavation with reasonable accuracy, it was recommended that the topmost exploratory tunnels should be extended at least 200 feet into fresh, strong rock. For the lower tunnels it would be sufficient if they were extended up to sound rock after overlapping the weak portions of the immediately overlying tunnel. The two axial tunnels at R.L. 400 should be extended up to the ends of the dam. The slate bands should be explored by boring, and percolation tests should be carried out.

The existing map of the Kosi gorge extends from the dam-site area down to Sona Khambi *nala*. For diversion tunnel and railway alignment work in future, this map should be extended up to Barahakshetra. A large scale map of the gravel bar near Chatra will have to be prepared before prospecting for concrete aggregate can be started.

Since the progress of tunnelling had quickened, and boring was expected to start soon, it was decided to keep Mr. S. C. Awasthi at the dam-site as the resident geologist. He was initiated to the geology of the area by Mr. Dutta.

Dr. J. B. Auden visited the Kosi dam-site between November 27th and December 3rd, 1948, during the last two days making a joint inspection with Dr. J. L. Savage, American Consulting Engineer. A detailed study of the 26 exploratory tunnels was made, which by then exceeded 6,000 feet in length. He agrees with Mr. K. K. Dutta's conclusion of April, 1948, that several bands of slate occur interbedded with the Kosi Dam quartzites, and that there are numerous sheared coal lenticles and seams in the series. The slates dip at steep angles and would rest with truncated edges against the dam structure. They will require excavation and back-filling with concrete in order to dissipate the stresses into the adjacent quartzites. Open slumps joints, indicative of gravitational settlement, occur in several of the tunnels even at the 600 feet elevation, which would be 500 feet below full reservoir level as then envisaged. Dr. Auden considers that no progressive improvement is found in the nature of the rock away from the surface, remarking that sound zones alternate with weak zones, and that the foundation treatment required will be extensive. He has attempted to delineate the approximate foundation contours of the dam after unsound rock has been removed, and suggests that an average of 160-250 feet horizontal would have to be removed between the 400 and 800 elevations on the left bank, and 120-230 feet on the right bank. Data for the critical river section, which is 300 feet wide, are totally lacking and it is not known either how deep the gravels are in the bed of the river or if any major fault zone occurs along the axis of the gorge. The exploratory drill cores have not given high percentage recoveries, which is thought to be due very considerably to the fractured and brittle nature of the quartzites, and the presence of sheeted quartzites and slates. The rock recovered from the holes is however fresh, a feature which is to be expected in as much as most of the cores have been obtained from rock below river level.

The spillway is to be located over the dam, with the great fall of 730 feet. On hydrodynamic grounds the Project Officer, Colonel Balwant Singh Nag, would prefer to rotate the axis of the dam so that the left abutment is located further south. The rotated position would have the advantage of removing the left abutment from the conspicuous zone of slates found at the upper elevations at the present alignment, but no position of the dam will entirely escape important slate and sheeted zones. Detailed recommendations were made regarding extensions of the main headings of some of the drifts, and the driving of cross cuts and new tunnels. The drilling programme should be concentrated for some time in the river section in order to determine the contour of the rock bottom. Until this has been done it will not be possible to drive the under-river tunnel which is essential for an accurate determination of fault features in the base of the dam.

Dr. Auden points out that 2½ million tons of cement would be required for a dam containing 15 million cubic yards of concrete. This quantity of cement is more than the total peak annual production of both India and Pakistan together in 1945. With a five-year schedule of concrete laying, up to 1,500 tons of cement would be required daily. The supply of this amount is one of the major problems of the project.

Dr. Auden states that a study of recent aerial photographs shows that the young inter-Nahan fault forms a remarkably straight feature, with every appearance of youth, and extends for a distance of three miles between grid coordinates 900:097 and 950:080 in map No. 72 N. This fault deserves further examination with regard to possible recent displacements, since it lies only 2,000 yards south of the Kosi dam-site and may be seismic. The straightness of its course across varied topography suggests that in the main the fault plane has a steep angle with the horizontal, notwithstanding local indications of a lesser dip.

The location of the seismographs was also discussed and it was pointed out that any instrument placed now in an exploratory tunnel would be subject to incessant extraneous vibrations from blasting, transport and concrete operations. It is considered necessary to avoid the immediate area of the dam-site, and to locate instruments at Chatra and near Barahakshetra.

MAHANADI PROJECT

Hirakud Dam-site, Mahanadi river, Orissa.

Dr. J. B. Auden visited the Hirakud Dam-site at the end of August, 1948, discussing accessible features with the resident geologists, Messrs. V. S. Krishnaswamy and M. C. Basu. In his report he points out that there are not at present sufficient boring data for a decision to be made on the relative merits of the alternative alignments, particularly near the right abutment where the maximum divergence occurs. He suggests that at least ten diamond drill-holes are required, five on each alignment, in the southern branch of the Mahanadi before the foundation conditions are satisfactorily explored. Rocks encountered in drill-hole 124 on the old alignment suggest the presence of Cuddapah arkoses and micaceous flags in the bed of the river. There is also a somewhat uncertain record of gneiss near the top of this boring. If this is substantiated, it follows that either a faulted contact has been struck between the Archaeans and the Cuddapahs or that there may be post-Cuddapah granitic rocks. Messrs. Krishnaswamy and Basu are following up this problem and consider as a possibility that the presumed Cuddapahs of the ridge on the right bank may in fact belong to the Archaeans.

It is not considered necessary that the tunnel on the left bank should be extended 100-150 feet to strike the contact between the pink silexite and the ortho-gneiss. This contact, which should be explored in view of the possibility that a brecciated leaky zone may run parallel to the valley and form an avenue of percolation, could be more economically explored by an angle hole higher up on the left abutment.

Dr. Auden suggests three locations for extraction of the major part of the impervious earth-fill, of which 163 m.c.ft will be required. These are: (*a*) between Samtang and Bartang villages; (*b*) between Parta and Sarsmal villages, although this area would involve haulage over the left abutment ridge; (*c*) Chilantikud island. It is considered necessary to prepare a large survey (32″=1 mile; with contours at 5-foot intervals) of an area of about 3½ m.sq.ft. around Silipathar, before the reserves of sound material for concrete aggregate can be properly estimated. With the present designs, it will be necessary to locate an area capable of providing 20 m.c.ft. of stone *in situ*.

Mr. V. S. Krishnaswamy, Assistant Geologist, was engaged in the detailed investigation of the Hirakud Dam-site. His observations regarding the foundation features are as follows.

The joints in the bed-rock along the proposed dam-axis change both in strike and dip, in conformity with the change in foliation of the bed rock.

The left abutment on which the earthen section of the dam will rest consists of highly weathered, friable to blocky ortho-gneisses with a few bands of silicified rocks. The main zone of silicified rocks is cropping out at a much higher elevation than the crest of the dam. The tunnel on the left abutment, which has advanced up to 68 feet, has not reached sound rock suitable for the termination of the cut off wall for the earthen section.

The right abutment ridge consists of massive, arkose quartzites, with bands of siltstones, shales, slaty shales, etc., all folded together into a syncline pitching northwards (towards the river). The easterly slopes of the ridge are covered by talus material, and further exploration would determine whether shaly or slaty bands occur beneath the talus cover, and underlie the quartzite, which is exposed in the tunnel at elevation 615. The tunnel has not reached fresh and sound rock, suitable for foundation of the concrete dam, and minimum excavation would extend beyond the face of the tunnel at 38′.

The completed drill holes between the left abutment and the left bank of the river indicate adequate cut-off foundation for the earthen dam at shallow depths. But the test-pits sunk in the Hirakud and Koilarikud islands reveal extensively weathered bed-rock that would have to be excavated under a concrete dam, and this fact is worthy of engineering cognisance in reaching a decision on the relative merits of having two separate or one single concrete section in the design of the dam.

As a result of investigation it has been found that the area along the left bank and in front of the left abutment can supply suitable material amounting to one third of the total requirements of the main earth dam. Further prospecting in the Hirakud island, and in extension of the area in the reservoir portion along the left bank of the river is necessary.

Three areas have been located as possible sources of concrete aggregate. Detailed investigation is however necessary for establishing the shape, extent and nature of the aggregate material and available quantities.

Originally exploration was being carried out according to a programme based on the design put forth in the Project Report, Hirakud Dam, June, 1947. Later an expert committee on the Hirakud Dam Project proposed a change in the axis of the dam by rotating it approximately 3° upstream from the left abutment and invited geological opinion.

Mr. Krishnaswamy is of the opinion that on geological grounds the design with two concrete sections is to be favoured, as it utilises to the best advantage the sub-surface foundation features.

Of the two alignments of the dam-axis, the original one appears more favourable in regard to the foundation of the right concrete section. Hence it is considered advisable first to explore the sub-surface conditions along the new alignment, and to ascertain whether deeper foundation excavation would be required, and whether in the overall analysis it would be economical.

An exploratory programme has been prepared in order to provide design data for the modified proposals of the Experts Committee.

If it is thought advisable to shift the axis of the dam, on engineering grounds, an alternative location has been suggested in between the old and new alignments, and preferably parallel to the former.

NARBADA RIVER PROJECTS

Narbada river, Punasa Dam-site, Central Provinces; Harinphal Dam-site, Central India.

The regional development of the water resources of the Narbada river has recently come under investigation by the Central Waterpower, Irrigation and Navigation Commission, New Delhi. The Geological Survey of India was asked to advise about the nature of two dam-sites, one near Punasa, 34 miles N.N.E. from Khandwa junction, the other 14 miles west of Barwani. This was done by Dr. J. B. Auden and Mr. G. C. Chaterji during a period of one week in April and May, 1948.

At the Punasa site (55 B/7; 22° 17′:76° 28′) it is proposed to construct a concrete dam 250-300 feet in height with a storage capacity of possibly 21 million acre-feet. A compass and tape-measure survey was carried out to show the principal geological features. The rocks exposed belong to the Upper Vindhyans and dip 15°-25° N.N.W., with numerous minor rolls, some sharp local folding and several shear zones aligned more or less along the strike. The strike runs oblique to the gorge which is orientated W.N.W.-E.S.E. The succession in the reach examined consists of banded green ripple-marked siltstones at the bottom, followed by grey-white and purple quartzites, grits, pebble-beds, purple siltstones and grey-white current-bedded quartzites.

Two major faults are aligned W.N.W.-E.S.E. and appear to determine the course of the river in the area examined. Neither fault probably extends far laterally, but the effect in the gorge is to cause a downfaulted wedge. In addition there are two low-angle thrust faults dipping W.N.W. which have produced considerable drag in the quartzites.

The left abutment forms a dip slope in which the dip of the strata has a component in the direction of the gorge of 10°-15°, which is considerably less than the declivity of the bank. Clays and shales are not noticed in these quartzites, and the authors consider that the coefficient of friction will be sufficiently high to prevent sliding of the quartzites, particularly when they form a mutual support with the dam. Much excavation will be required, however, before foundation grade is reached, on account of the influence of surface creep and slight gravity settlement on this bank. The right abutment is a scarp slope which dips into the hill side, and is freer from creep effects.

The site originally selected by the engineers is at the east end of the gorge and includes a considerable outcrop of the green siltstones. These rocks on exposure develop numerous irregular concentric cracks and would require very careful treatment during foundation excavation. In view of this fact, the existence of more suitable quartzites further west, and the very interrupted profile which would arise with the provisionally adopted alignment, Dr. Auden and Mr. Chaterji would prefer a site within a reach of 1,000 feet from 1,500 to 2,500 feet further west. They consider the gorge suitable for the construction of a dam of up to 300 feet in height, but state that the final alignment cannot be selected until detailed topographical surveys have been carried out and a geological map made in which all the weak zones are demarcated. It will then be possible to locate the axis in the site which is least affected by faults, shears and folds.

Harinphal (46 J/12; 22° 02′ 30″:74° 41′) is located on Deccan traps which are traversed by almost east-west dolerite dykes up to 200 feet in width and thinner acid porphyry dykes occurring as clusters.[1] Several types of trap are present, varying from compact aphanitic and porphyritic basalts to amygdaloidal basalts with vesicles of agate and soft *moorum* trap which weathers easily. Bearing strengths should on the whole be high though the soft zones will need consolidation treatment. The main point to consider is the possibility of sliding between the horizontally disposed basalts, should inter-trappean clays occur at a shallow depth in the foundation of the dam. Another point requiring investigation is the possibility of leakage, which must be tested by water-tests in the exploratory drill-holes. The dykes will run across the axis of the dam and exploration to prove the nature of the foundation rock should include angle holes to study the possibly brecciated and leaky vertical contacts between the dykes and the lavas. There is little on geological grounds to choose between the site actually at the Harinphal temple and one which is 1½ miles downstream thereof, but the former site is more accessible and would entail a lower dam for the same storage. Raw materials for çement and aggregate are discussed in the report.

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[1] J. B. Auden, Dykes in Western India: *Trans. Nat. Inst. Sci. Ind.*, III, pp. 123-157, (1949).

NAYAR PROJECT

Marora dam-site, Garhwal district, United Provinces.

Visits were made by Dr. J. B. Auden to the Marora dam-site in January and May, 1948. After a critical review of the geological conditions exposed in the tunnels Dr. Auden discusses in his report of February both the main river-fault, with an average true thickness of 80 feet filled by clay gouge and broken sheeted slates, and the four intersecting sets of divisional planes which permeate the whole Simla Slate formation, three of which are accompanied by clay gouge. He is concerned with the open fissures that occur along the vertical W.N.W.-E.S.E. joints which are regarded as indicating gravity settlement. The right abutment is held to be potentially liable to slips along slip circles bounded by: (*a*) the open vertical joints; (*b*) the closely developed cleavage planes which are inclined gently and obliquely upstream with a considerable component of dip into the gorge; (*c*) the satellite river-fault pattern of planes which are roughly parallel to the right wall of the canyon. He points out that there is no progressive improvement in the nature of the rocks away from the hill face, for important zones accompanied by clay gouge occur far into the hill side in some of the tunnels (*e.g.*, T. 33).

The generally unsatisfactory nature of the abutments was thought by him to be serious in the case of a dam which would be 600 feet in elevation above low-water level, and he was led to consider that the site might be unsatisfactory for a concrete dam of such great dimensions, and very costly in view of the great amount of excavation which would be required.

Subsequently Dr. J. L. Savage, U. S. Consulting Engineer, re-visited the site and considered it to be feasible. In May, 1948 he and Dr. Auden visited it together for a joint inspection. Dr. Auden's report of June, 1948 stresses the importance of the open joints and repeats that there is no progressive improvement into the hill side, a feature shown by the tunnel cross-cuts recommended by Dr. Savage in March, 1948. Much poor rock must therefore be left in the foundation, and the treatment of the bad features in the foundations may prove very difficult in cases where clusters of clay seams occur. He states that, in his view, the site is not comparable to others in the U.S.A. on which successful dams have been built, and regards the combination of: (*a*) recent rapid river erosion; (*b*) gravity settlement; (*c*) intersecting clay seams, some predisposing the right abutment to landslipping; and (*d*) monsoon conditions, as presenting peculiar problems for a dam of such a great height. For a low dam, of 200-300 feet, the problems would have been much fewer, apart from the treatment of the main river-fault.

Nevertheless, he points out that geology is not an exact science and that more than one interpretation may be possible on available evidence. He states that his own attitude to the problem of this dam-site may have been rendered unduly pessimistic by earlier studies of Himalayan tectonics, earthquakes and landslips, and he now accepts Dr. Savage's opinion on feasibility. Further extensions of the main headings and cross-cuts were outlined and it was recommended that the independent advice of a geologist experienced in the treatment of bad foundation conditions should be called for during the cold weather of 1948/49 to provide a final opinion.

RAMGANGA PROJECT

Kalagarh dam-site, Ramganga river, Garhwal district, United Provinces.

Dr. J. B. Auden paid two visits to the Kalagarh dam-site, Ramganga river, in January and May, 1948. The site accepted for investigation by the Irrigation Engineers of the United Provinces had been previously selected for an earth dam by Dr. Auden in December, 1943 and discussed in a report dated January, 1944. The present proposal is to construct an earthen dam 330 feet in height above river level, with a base which will probably be 2,200 feet in thickness from upstream to downstream toe (53 K/14; 29° 31′ 13″ : 78° 45′ 30″). The design includes an impervious clay core 300 feet thick dipping upstream at an angle of 30°. Approximately 5·85 million cubic yards of impervious fill will be required.

The general geology of the area is first discussed and a map has been prepared of 500 square miles, based on Dr. Auden's traverses combined with the earlier surveys of C. S. Middlemiss. The dam itself would rest across the arbitrary junction of the Lower and Middle Siwaliks, which consist of regular alternations of sand-rock and clay shale dipping 30° to 40° N.N.E. The strike of the rocks is almost exactly parallel to the axis of the proposed dam, both strike and axis being somewhat off perpendicular to the axis of the gorge. Eight pairs of sand-rock and clay-shale, each unit with average true thickness of 90 feet, occur in the relevant reach of the river. The clay-shales will act as impermeable barriers, dipping upstream, to the percolation of water. It is not considered that any serious fault traverses the area which would be occupied by the dam. As at present aligned, the impervious clay core section of the dam will abut fully against only one band of clay-shale, 90 feet thick, most of the core being contiguous with sand-rock. Dr. Auden indicates that a detailed geological survey is required, with exact demarcation of each permeable and impermeable set of beds, before the final decision is made as to the best position of the clay core in relation to the most suitable bands of clay-shale.

The alternative dam-site further upstream on the Ramganga river at longitude 78° 44′ 33″ must be ruled out because the right abutment would be a dip slope of sand-rock and clay-shale which is now in active process of landslipping.

Material for the clay core will probably be derived from the clay-shales, the best location being regarded as on the right bank of the river just upstream of the western diversion tunnel. It is possible that 30 million c.ft. of gravel terrace deposits will be available on the left bank of the river between north-south grid lines 4138100 and 4138600. Much of the pervious section of the dam may have to be obtained from terrace and bed gravels upstream towards Boksar or downstream below Kalagarh.

A detailed programme of investigations by means of diamond-drill-holes was laid out by Dr. Auden and Mr. S. P. Nautiyal. The existing map on the scale of 32″=1 mile, which was prepared from aerial photographs, is not very accurate and it was recommended that rigid ground surveys should be carried out in order to enable the complete plotting of geological features regarding the foundations and the locations of construction materials.

SUTLEJ (BHAKRA) PROJECT

Bhakra dam project, Sutlej river, East Punjab.

Due to prevailing unsettled condition resulting from the partition of the Punjab, further activities at the Bhakra dam-site were suspended from July, 1947. During April, 1948, Mr. P. C. D. Hazra visited the dam-site to continue the remaining exploratory work. His visit coincided with that of Dr. J. L. Savage, Consulting Engineer from the U.S.A.

Mr. B. K. Baweja, who accompanied Mr. Hazra, was initiated into the current exploratory work and he stayed at the dam-site as the resident geologist. Mr. Hazra paid two more visits of inspection to the dam-site during the year under review.

Proposal to raise the height of dam.

Originally the height[1] of the dam was fixed at R.L. 1580, but as a result of further negotiation with the Raja Saheb of Bilaspur and due to the new political set-up, the 1944 Agreement between the State authorities and the Punjab Government restricting the height of the dam was waived. The Chief Engineer, P.W.D., East Punjab, informed Mr. Hazra that it was now decided to raise the height of the dam by another 50 feet, *viz.*, up to R.L. 1630, and wanted advice concerning further geological investigation required in this connection. Accordingly two more axial drifts on the either abutments to be driven 50 feet into sound rock were recommended, at R.L. 1650 and R.L. 1700.

During Mr. Hazra's subsequent visit to the dam-site in July, 1948, he was asked to advise on the safety of further raising the height of the dam up to R.L. 1700 in view of extra supplies of water required for Bikaner State As the exploration carried out between 1945 and 1947 related to a dam of much lesser height, Mr. Hazra advised the engineers that a fair amount of fresh exploration would be needed before a definite conclusion could be drawn regarding the maximum safe height of the dam.

Exploration for a higher dam up to R.L. 1700.

As the downstream toe of the proposed dam will be displaced by 100 feet or so towards the Haneri *choa* if the height of dam is raised by 120 feet, (up to R.L. 1700), Mr. Hazra recommended that a string of three river holes, equally spaced across the "Narrows" and located along 18/75 chain should be drilled up to 75 ft. into good rock for testing the foundation conditions. Moreover, three tunnels at elevations 1400′, 1500′ and 1600′ should be driven 50 feet into good rock along the contact of the new (extended) downstream face of the dam with both the abutments. The new drifts at elevations 1650′ and 1700′ which had not reached good rock at the time of his visit were directed to be continued.

Maximum safe optimum height of the dam.

In December, 1948, Mr. Hazra paid another visit to the dam-site, when he examined the new high level drifts and the core obtained from the river bed. He is inclined to think that it would be quite feasible to raise the height of dam up to R. L. 1680. A higher dam would mean very expensive foundation treatment. The depth of weathering increases with the height of dam and the condition of the left abutment is unsatisfactory where open joints and bedding planes containing infiltration of clay and gouge persist up to 150 feet (at elevation 1600′) from portals. However, as hard massive sandstones are involved, it is expected that stripping would not be very deep and that it would be possible to grout open bedding planes and joints after washing.

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[1] *Rec. Geol. Surv. Ind.*, General Report for 1947, 81, Pt. 1, p. 89, (1949).

Re-location of the power houses, Bhakra dam project.

As a safety measure against aerial attacks the power houses at the Bhakra dam are proposed to be located in tunnels. Mr. Hazra advised that the best location of tunnels for accommodating the power houses would be in the massive sandstone of the "Narrows"—the portion of gorge between 18/50 and 19/50 chains.

Diversion tunnels, Bhakra dam project.

During his inspections of the Bhakra dam-site in April, July and December, 1948, Mr. Hazra examined the pilot headings in the projected 50 feet diameter diversion tunnels. Necessary advice regarding the difficulties to be encountered during tunnelling and suggestions to overcome these were also given to the engineers.

Due to the difficulty of suitable foundation for the portal of the right diversion tunnel, which had to be located on claystone, Mr. Hazra recommended that the open cut (approach channel) should be extended up to the sandstone member downstream. His suggestion was approved by Dr. Savage, as such a change would not interfere with the construction of the upstream coffer dam. So far serious water trouble has not been encountered, but it is expected that when the headings cross the parallel strike faults and the Middle-third clay zone, serious water trouble accompanied by roof-fall would be met. The progress in the claystone has been slow due to the need of close timbering, but a fairly high rate of progress was maintained in draining through the massive sandstones which do not require any support. Up to the end of December, 1948, the total footage driven amounted to 1700 feet and 1250 feet in the left and right diversion tunnels (pilot headings) respectively. Geological sections along the pilot headings have also been prepared.

Stability of hillside and deep open cuts for rail-road, Bhakra dam project.

Deep open trenches, measuring over 100 feet in depth in some cases, have been cut along the left side of the Bhakra gorge between Mohaka *choa* and Haneri *choa* for taking the rail-road up to the dam-axis. In December, 1948, at the request of the Executive Engineer, Bhakra Dam, Mr. P. C. D. Hazra advised on the stability of the hillside and the deep trenches with almost vertical sides. According to him, there is a serious danger of slides or rock-fall from the upper levels of the trenches as well as on the hillside due to vibrations set up by locomotives, especially as the rocks are highly jointed and in many cases the joints are filled with clay seams. The remedy lies in either trimming the vertical sides of the trenches to at least ¼:1, or providing a concrete arch ("cut and cover") on the top of the rail-road as a measure of protection against falling rocks.

Railway tunnel, Barmala, Bhakra dam project, East Punjab.

During April, 1948, Mr. Hazra examined the 1094 feet long railway tunnel near Barmala with Mr. B. K. Baweja and prepared a geological section. At the time of his visit the work of widening and lining the tunnel was in progress. As anticipated no trouble of any serious nature was encountered during tunnelling.

Water-supply, Nangal township, Bhakra dam project.

At the request of the Superintending Engineer, Bhakra Dam Circle, Mr. Hazra advised on the best location of a well to supply water to the new township. A site about half a mile north of the town and on the side of a small dry *nala* joining the Sutlej river has been selected. It was recommended that the diameter of the well should not be less than 16 feet, and it should be taken at least 15-20 feet below the water table.

Nangal Weir, Sutlej river, East Punjab.

During April, 1948, Mr. Hazra advised the engineers on various foundation problems at the Nangal weir-site. It was considered that if the grout holes (placed at 5 foot centres) in the cut-off were taken about 20 feet down, the possibilities of leakage would be totally cut out, and the structure would be made quite impervious. The provision of a grout curtain was also suggested. Mr. Hazra had the benefit of a discussion with Dr. J. L. Savage, who was also present, in answering many questions, some of which were of purely engineering character.

OTHER PROJECTS (MULTIPURPOSE, HYDEL AND STORAGE)

ASSAM

Dihang River Project, Abor Hills, Assam.

Dr. A. K. Dey made a preliminary examination of sites for a dam on the Dihang river near Rengging (28° 08′: 95° 47′) 6½ miles north-west of Pasighat in the Abor Hills, Assam.

The valley of the Dihang at Rengging is made up of alternating bands of hardened grey shale and argillaceous limestone, usually brecciated and with fractures filled with calcite. Further upstream, from near the mouth of the Sirpu stream to beyond the confluence of the Yamne, lava flows are found interbedded with the shale, limestone, sandstone and quartzite. The rocks seem to strike in a north-westerly direction, and have very steep dips. The river flows approximately along the strike of the rocks. A favourable site, with alignment not much inclined to the structural plane of the bed-rocks, and with an interbedded lava flow acting as an impervious apron, may be found about a mile upstream of the Sirpu, where the Dihang takes a zigzag course through a narrow steep-sided valley. It would, however, be necessary to investigate the locality thoroughly so that a site with the least number of defects may be selected. The borings will show whether the joints, fractures, etc., close in depth. The area is also liable to destructive earthquakes. Dr. Dey found the locality difficult of access, owing to steep valley walls, and strong rapids in the river. No large scale map of the locality showing details of topography is available. Dr. Dey, therefore, suggested that the rock ledges causing rapids in the river should be blasted out to make the locality accessible by boat, and that an aerial map on the scale of 4″=1 mile should be made to aid detailed investigation.

Flood Control in Manipur State.

At the request of the Chief Minister, Manipur State, Dr. A. K. Dey visited Chapki Karong (24° 12′: 93° 55′) to devise measures of flood control in the Manipur river near its confluence with the tributary Chakpi. The divide between the Manipur and the Chakpi is a ridge made up of steeply dipping sandstone and shale striking N.N.W.-S.S.E. The surplus water of the Chapki may be drained into the Manipur river about six miles below the confluence by constructing a channel with a northern bund and weir from below Chapki Karong westwards to Kambung where a low saddle in the ridge will have to be cut deep to connect the channel with the valley of the Manipur. In the absence of a large scale map (largest scale maps available being 1″=2 miles) it was not possible, within the limited time available, to examine the area in any detail; but the scheme has been discussed with the Chief Minister, Manipur State, and before further investigation of the scheme is undertaken its economic aspect should be considered by the State authorities.

WEST BENGAL

Tilpara barrage, Mor Project, Birbhum district, West Bengal.

In March, 1948, at the request of the Superintending Engineer, Mor Canal Circle, P.W.D., Irrigation Branch, West Bengal, Mr. P. C. D. Hazra visited the Tilpara barrage-site (sheet 73 M/9; 23° 57′: 87° 32′) to examine the cores obtained from D. H. Nos. 8 and 8B put down on the edge of the right bank of the Mor river, and to advise the engineers as to whether the drill-holes had proved sound rock. Mr. Hazra found that both the holes, which exceeded 50 feet in depth, had already reached good rock and he accordingly advised the engineers that further drilling was unnecessary. The D. H. No. 8 struck granite gneiss at 35 feet whilst 8B met the same rock at a slightly lower level, *viz.*, at 47½ feet. The first hole was in granitic rock throughout, but the second one passed into a basic rock, probably a dyke, at 47 feet, 4 inches, and remained in the same rock up to the end of the hole at about 52 feet.

BOMBAY

The examination of some dam-sites on the Tapti river in Baroda State and on the Narbada river in Rajpipla State was done by Mr. M. S. Balasundaram in the company of Mr. G. N. Pandit, Project Officer, Narbada and Tapti, Central Waterpower, Irrigation and Navigation Commission, in November-December, 1947.

Arkati dam-site, Tapti river, Baroda State, Bombay Presidency.

The Arkati dam-site (46 G/15; 21° 23′: 73° 50′) is situated four miles north-east of Vajpur (46 G/15; 21° 20′ 45″: 73° 46′). The reservoir up to the 400 foot contour will have a storage capacity 45,000 million cubic feet. The dam may be about 200 feet high. There are two alignments, measuring roughly one and three-fourths and one and half miles. The abutments are underlain by basalts which are jointed, E.-W. joints being prominent. The Tapti here flows through a broad U-shaped valley with high banks (60-70 feet). There are no rock outcrops either on the banks or in the bed of the river. There is a considerable thickness of black cotton soil cover on the left bank.

Tikarwa Khurd Dam, Tapti river, Baroda State.

Tikarwa Khurd dam-site (46 G/11; 21° 19′ : 73° 43′ 30″) is located three miles S. 60° W. of Vajpur. There are two alignments one mile one furlong and seven furlongs long. The geology of this site is more or less similar to that of the Arkati dam-site.

Other conditions obtaining at both the dam-sites discussed above are almost the same. The left abutment hills are far removed from the left banks, circumstances which are not ideal but cannot be avoided. Mr. M. S. Balasundaram recommends bore-holes 500 feet apart along the alignments to find out the thickness of overburden, the thickness of different flows of trap and other structural characteristics such as joints, crush zones, faults, dislocations, soft zones, etc. The bore-hole in the middle of the river should go to 100 feet and for other holes it is enough if the depth reaches hard rock at 25 feet. He concludes that basalts are hard and sound rocks which are quite suitable for the foundation of a concrete dam. The chief drawback to them is their horizontal bedding and vertical joints and sometimes the presence of a soft inter-trappean bed between two lava flows. The presence of amygdales in the amygdaloidal basalt are not expected to weaken the rock. Lastly he says that it is difficult to decide at this stage which particular site is the best. Tentatively it may be said that the Tikarwa Khurd alignments being shorter and having greater storage capacity and also containing a fewer number of gaps to be closed, are preferable to the Arkati dam alignments.

Kakarapar weir-site, Surat district, Bombay.

The Kakarapar weir-site is situated west of the Kakarapar village (46 G/7; 21° 16′: 73° 22′). It will be a low weir about 20-25 feet in height. The country rock is amygdaloidal basalt. Besides horizontal bedding it has developed two sets of vertical joints. At this site the right bank of the river, 20 feet high, is built of sand and clay and the left bank is rocky. The bed of the river is mostly rocky throughout. Mr. Balasundaram observes that due to the absence of a rocky abutment in the right bank, the weir on this side should be an earthen embankment suitably faced by rip rap, or the upstream side given a coat of concrete. There are pot holes present in the rock exposures in the bed of the river near the left bank. These and the joints would involve using large quantities of cement for pressure grouting. The Kakarapar weir site is likely to prove to be a good site.

Weir-site, Narbada river near Gora, Rajpipla State.

Mr. M. S. Balasundaram examined a proposed weir-site near Gora (46 G/9; 21° 52′ : 73° 41′). It will be a low weir 30 feet in height. The width of the river is about half a mile. The site is underlain by amygdaloidal basalt dipping upstream towards the south. There are rock outcrops on the left abutment as well as in the bed of the river. Due to the lack of rock outcrops on the right bank, this side must be an earth section. Mr. Balasundaram concludes that the site is quite suitable for a weir, and he recommends the sinking of half a dozen bore-holes spaced at equal intervals, down to 25 feet in hard rock. A bore-hole in the middle of the river should pierce 50 feet of rock.

Limdi dam-site, Narbada river.

Mr. M. S. Balasundaram also examined a site for a one mile long and probably 375 feet high dam at Limdi (46 G/9; 21° 50′ : 73° 43′). The reservoir created by such a dam would have a storage capacity of approximately 9·80 million acre feet. It would bring about one million acres under irrigation and may produce well over 200,000 KW. of electric power. The Limdi dam-site appears to be an ideal one from the engineering point of view. The river section is deep and narrow (main deep channel 100 yards wide) with high hills closing on the river. The rocks exposed in the bed of the river as well as in the abutments are fairly fresh, and are likely to prove to be good for the foundation. The left abutment and the bed of the river reveal basaltic traps having horizontal bedding and vertical joints. The traps contain calcite crystals and rarely quartz crystals in cavities. The right abutment will be on quartzites where a fault appears to end. The faulted boundary of the trap and the quartzites falls close to the downstream toe of the dam. Besides, there are two open fissures which traverse the river trending obliquely to the banks. Mr. Balasundaram observes that the site deserves further geological investigation in order to give a definite opinion as to its feasibility. He suggests drilling operations to investigate the following : joints, fissures, faults, presence of inter-trappean beds, thickness of lava flows, degree of decomposition of the traps, water pressure tests at frequent levels below the surface to note losses, if any. He has also advised a detailed study of the limestones in the 'Bagh beds' to find out the quantity and quality of limestone available for the manufacture of cement.

Kalinadi Project, North Kanara district, Bombay.

In pursuance of a request from the Associated Consulting Engineers, who are acting as consultants of the Bombay Electric Grid, Dr. B. C. Roy examined the exploratory work carried out in connection with the Kalinadi project and investigated the dam-sites concerning the Kaneri and Baginkatte schemes.

A traverse along the proposed Nagjhiri tunnel, aided by the data of four percussion bores, shows that barring the extreme end of the alignment, commonly covered by 5-15 feet thick *moorum*, most of the alignment is capped by a black or brown soil, generally varying in thickness between 20 and 25 feet. The tunnel will have a cover of 200-300 feet over most of the alignment. In the N.E.-S.W. trending part of the alignment, the strike of the formations being N.-S. to N.N.W.-S.S.E., the tunnel will be inclined to the strike at angles between 45° and 67°, indicating large overbreak. The strike direction in the N.N.E.–S.S.W. trending portion of the tunnel varies between N.–S. and N.N.E.–S.S.W. This implies that parts of the tunnel will be inclined to the strike at a small angle of 20° or will follow the strike of the rocks. Thus considerable overbreak may be anticipated in some parts, although there would be easy driving in portions of the tunnel. No serious water trouble is envisaged in the phyllites and quartzites.

Two sites for a dam across the Kaneri river, a tributary of the Kalinadi, were examined. At Bower's site, about twelve miles upstream of the river from its confluence with the Kalinadi, a 150-200 feet high dam is possible. Here the river bed exposes banded hematite-quartzites, dipping downstream at 60°-70° towards the east. The abutment rocks are loose and excavation up to a depth of some 30-40 feet may be necessary to reach the rock of foundation grade. At another site, about one and half miles downstream of Bower's site, where massive quartzites are exposed at the river bed and in the flanks, dipping 75°-85° towards E.N.E., *i.e.*, downstream or vertically, a 200 feet high dam is feasible. In view of some disturbance in the neighbourhood, it is suggested that the axis of the dam alignment be shifted a further 300 feet upstream.

Three dam sites were examined in the Baginkatte river, another tributary of the Kalinadi. The lower dam-site shows quartzites dipping nearly at 30° towads E.S.E., at the river bed, but considerable stripping at the flanks, consisting of reddish soil and talus, will be needed. The middle dam-site concerns a much narrower gorge, about one mile upstream of lower site. The upper site, about two miles upstream of the middle site, envisages a much longer dam. The geology of both the middle and upper sites is identical, consisting of a series of alternate bands of coarse or fine quartzites, striking N.-S. and dipping 15°-25°, mostly eastwards and sometimes towards the west. Considerable stripping will be required at both sites at the abutments to reach foundation grade rocks.

Koyna Project, Satara district, Bombay.

Dr. B. C. Roy also examined the Koyna project at the request of the Bombay Electric Grid. The pipe lines from the tunnel outlet are proposed to be laid along a precipitous edge of a cliff and over the unstable slopes of a ridge for a distance of about 6,000 feet. This would need an undercutting for some 50 feet in the cliff and a removal of 40-50 feet of overburden for fixing the anchor blocks along the ridge. Dr. Roy contends that the length of the pipe lines may be minimised by as much as 80 per cent., if the tunnel outlet is shifted some distance to the north, and the pipe lines laid from the tunnel exit along the scarp slopes of the traps down to the bottom of a valley, where the power house could be located. This would mean some loss of head which, however, could be overcome by further extending the pipe lines from the bottom of the valley along a well marked channel, above the flood water level to the originally proposed power house site. The necessary survey along the proposed alignment is recommended.

Judging from 15 borings in the right bank of the Koyna river, staggered along the dam-line, it appears that although the traps occur within five feet from the surface at the right edge of the river bed, considerable stripping of the order of 20 to 120 feet would be needed to reach the traps of foundation grade along the right abutment. Nothing definite can be said at present regarding the extent of stripping that would be required at the left bank abutment, unless the record of borings is available; but considering the two bores (Nos. 37 and 5), it appears that the rocky floor slopes towards the left abutment for some distance at least and that a maximum excavation up to 70—120 feet should be envisaged in places.

Vaitarna Project, Thana district, Bombay.

The proposed dam-site and tunnel alignment, in connection with the Vaitarna Scheme[1], was examined by Dr. B. C. Roy at the instance of Mr. N. V. Modak, Special Engineer, Bombay Municipality.

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[1] *Rec. Geol. Surv. Ind.*, 81 p. 115, (1949).

The preliminary exploratory work, in the form of stripping and boring, show that provisionally the dam-site may be considered satisfactory and that excavation up to 30-40 feet will be needed in loose overburden (detrital soil, trap boulders and weathered traps) before reaching fresh traps in the flanks. The foundation rock exposed in the river bed consists of sound traps, with irregular but tight joints. Boring in the river bed is essential and it must be carried down to a depth of 100 feet. In addition, the borings at chainages 0/215, 0/370 and 0/451 (left bank) and at chainages 0/755, 0/943 and 0/1,192 (right bank) should be deepened to 125-175 feet. These will be helpful in correlating the various flows and will indicate possible permeable inter-trappean horizons.

Barring some open cuttings in soft traps in inlet and outlet portals and in the Balwant and Tasu *nala*-sections, the entire tunnel will be in bedded traps, presumably striking a few distinct flows, with variations in hardness, nature of jointing and manner of overbreak between flows. No serious water trouble is envisaged during the construction of the tunnel. Being a pressure tunnel with a head up to 118 feet, lining would be necessary to avoid percolation and frictional losses. In order to get an idea of the particular flows and any possible inter-trappean beds, it is advisable to put down three borings along the tunnel alignment up to tunnel level, at chainages 2,500 ; 13,500 and 20,250, and to drive two adits at chainages 9,300 (Balwant *nala*) and 12,000 (Tasu *nala*).

BOMBAY AND RAJPUTANA

Baroda-Idar-Gadhwara, Sabarmati river dam-sites.

In connection with a scheme for the multipurpose development of the Sabarmati basin Mr. G. C. Chatterji along with a party from the Central Waterpower, Irrigation and Navigation Commission undertook a joint inspection of dam-sites on the Sabarmati river in the Baroda-Idar-Gadhwara region (sheets Nos. 45D and 46A) of Western India and Rajputana in October, 1947. The proposal of damming the Sabarmati river for the purpose of irrigation has been considered by the Government of Bombay from time to time since 1890. The Government of Baroda later started systematic ground survey, boring and other investigations for a 99 feet high dam at Dharoi (45 D/12 and 16; 24° : 72° 54′) in 1935 which has since been completed. They also projected a 98 feet high pick-up weir at Ransipur (46 A/10 and 14; 23° 45′ : 72° 50′) in 1941.

Mr. Chaterji has stated in his report that the time which could be devoted to geological fieldwork at the sites, specially at Ransipur, Deira and Techawa, was very inadequate for any approach to systematic geological studies. More detailed investigation will be necessary before any of the sites is either accepted or rejected.

Dharoi site.

This is the main dam-site on the Sabarmati river and is situated near Dharoi village near the tri-junction of Danta, Idar and Gadhwara. It is at the foot hills of the Aravalli range. The Sabarmati river is discharged finally on to the alluvial plains near Dharoi.

The river flows in a south-westerly direction and girdles the Dharoi hill on the right. Its deep channel which carries the normal flow of the river is about 600 feet wide. The depth of water in the channel on the date of visit (12th October, 1947) was on an average about three feet. The actual river bed is 2,000 feet wide at the dam-site. From its left margin the ground rises gradually to the foot of the Ambawada hill at a distance of about 1,300 feet. The dam alignment is at right angles to the flow direction, *i.e.* roughly N.W.-S.E. Around the site steep irregular masses of hills are dotted over the open undulating country. At the dam-site the Sabarmati traverses a flat bottomed constriction in its valley between the steep rocky walls of the Dharoi and Ambawada hills on its right and left banks respectively.

The average elevation of the inhabited plains around is 650 feet above M.S.L. The elevation of the river bed is about 540 feet. The slope of the channel is gentle. The maximum altitude of the Dharoi hill is about 850 feet, while that of the prominence of the Ambawada hill near the left abutment of the dam is about 1,000 feet; but the maximum elevation available near Babsar (23° 59′ : 72° 56′), beyond which the left bank '*bundh*' would end, is only about 680 feet or so.

Coarse grained, hard and compact Erinpura granite is exposed on the abutments, and has been touched at depths between 20 feet and 35 feet in the river bed along the dam alignment. No boring has been done on the abutments, and the behaviour of the joints and fissures in the granite at depth has not been tested. The topography of the country around would permit of a dam up to 140 feet high, and the bearing strength of the granite bed-rock would be suitable for a masonry structure; but detailed geological investigation of the possibilities of leakage, etc. should be done before the site is finally accepted.

Ransipur site.

The Ransipur pick-up weir-site is aligned across the boundary of Baroda and Idar States between Ransipur and Eklara (23° 45′ : 72° 51′). It is the most southerly, *i.e.* lowermost site inspected. The older site of the Ransipur village is abandoned and the present site is where it is marked as Virpur (23° 45′ : 72° 50′) on sheet No. 46 A/10 and 14. The site is about 24 river miles downstream of the Dharoi dam-site.

The country around the site has a terrace topography. On the left bank the land surface is gently undulating with occasional flat topped mounds. The ground is, however, cut up by numerous *nalas* and depressions. The surface gradually rises to the east and north. On the right bank the ground is more severely dissected in multifarious directions by deep ravines and water courses with elongated flat topped hillocks and mounds in between. Away from the river on this bank the ground rises in steps forming contour platforms.

The river here has a southerly flow and has bifurcated into two channels, on either side of a low ridge. The right arm is the deeper and carries the normal discharge. The left arm 'whose bed is about 60 feet higher is understood to have been functioning some 65 years ago' and both the arms shared in carrying off the discharge. 'In recent years, however, it functions only during extraordinary floods'. It has been proposed that the main pick-up-weir would be on the right arm, and the surplus weir would be on the left arm. The alignment consists of two sections. The main weir strikes E.-W. from the right bank of the river about half a mile east of Ransipur and the surplus weir strikes N.E.-S.W. from the left bank, about 200 feet N.N.E. of the Dhareswar temple. Both the sections meet on the dividing ridge.

The river channel here is considerably constricted. At the top of the banks the main right hand channel is about 725 feet wide and the left hand channel is about 500 feet wide. The banks are very steep. The depth of the right bank near the present weir-alignment, east of Ransipur, is about 80 feet; and the depth of the left bank on the same alignment on the main channel is about 83 feet.

The soft alluvium covering the valley on both banks is extensively cut up along the river banks into bad land topography.

The exposed bed rock is coarse grained, highly felspathic Erinpura granite which is extensively kaolinised over wide zones up and down stream of the alignment. There are a number of working kaolin quarries on both banks. Seven borings were put down on the main river channel. These have established that: (1) there are deep vertical chasms in the solid bed rock, (2) the bed rock is in certain zones decomposed to depths of over 20 feet, and (3) there are a succession of horizontal fissures or weak zones which continue down to considerable depths (the deepest met with was at 61 feet) in otherwise undecomposed rock. A W.N.W.-E.S.E. vertical fault was met with at the entrance into the surplus channel. This site did not appear to be promising.

Deria site.

This site is in the rocky gorge of the river between Madhwa (23° 48′: 72° 51′) and Deria (23° 46′: 72° 50′). Jointed and fissured, coarse grained Erinpura granite forms the bed rock; and it is traversed by dykes and sills of dolerite. Some of the dykes running parallel to the direction of flow of the river are deeply decomposed and have often given rise to deep, vertical channels. Mr. Chaterji considers that even from a purely topographical point of view there are other sites within the Madwa-Deria gorge and also further downstream which may on investigation be found to be more suitable geologically for a 100 feet high dam.

Techawa site.

In the course of an aerial reconnaissance while flying low over the Sabarmati between Ransipur and Dharoi Mr. Chaterji was able to locate near Techawa (23° 46′: 72° 50′) a constriction in the river channel with rocky bed and banks, and a fairly thick dyke cutting across the river. Thereafter on ground inspection it was found that upstream of the dyke there is a deep pool; downstream of it the river cascades over block-jointed rocky outcrops with a fall of about ten feet in a hundred yards (eye estimation). The width of the water channel near the site is about 150 feet. The banks slope steeply, the depth above the water level being about 60 feet. The width at the top of the banks is about 700 feet. The ground contours in this region close up towards the river banks near the site. Within a short distance beyond either bank there are rocky mounds on undulating ground, which may support a dam higher than 100 feet. On both sides of the river there are deep *nalas* running parallel to the banks, which discharge into the main river at distances of half a mile to one mile downstream. These on examination may offer a solution for the surplussing arrangements.

The bed rock exposed on the entire river section is the coarse grained Erinpura granite, and the river has narrowed down considerably when crossing a 25 feet thick, hard and compact, doleritic trap dyke which cuts obliquely across the river. A masonry dam may be aligned along the dyke which would offer a natural cut off wall. As far as could be seen this site offers a good alternative to the Ransipur or the Deria sites. Mr. Chaterji recommended that more detailed investigation and large scale geological mapping around the site would be necessary before a final opinion could be given regarding its suitability.

CENTRAL PROVINCES AND BERAR

Wardha, Mahanadi and Narbada valleys in C.P. and Berar.

In connection with the proposal for the multipurpose development of some of the river valleys in the Central Provinces and Berar Mr. G. C. Chaterji undertook a rapid tour of preliminary inspection of some dam-sites, along with a party of engineers from the Central Waterpower, Irrigation and Navigation Commission and the Provincial P.W.D. The scope of work lay in examining the suitability of dam-sites, provisionally selected by the Central Waterpower, Irrigation and Navigation Commission.

Wardha river.

Thana dam-site (55 K/3; 21° 21′:78° 04′).—The site is covered by Older (Narbada) Alluvium resting on Deccan trap basalts which crop out on both banks of the river at some distance from the river channel. The dam would be nearly one and one-eighth miles long The site seems suitable, subject to confirmation by further investigation.

Mahanadi river.

Tumukalan dam-site (64 H/6; 20° 35′:81° 28′).—The bed of the river is flat, sand covered, with occasional gneissic outcrops. Right abutment: jointed, coarse porphyritic, granitic gneiss. Left abutment: block jointed, coarse to medium grained, granitic gneiss. This is overlain, on a flat topped plateau some distance away from the river, by grey quartzite. Basement rock is sound, but detailed investigations regarding the behaviour of the joints will be necessary before the final selection is made.

Pairi river.

Baruka (20° 43′:82° 00′; 64 H/14) and *Nirai* dam-sites (20° 40′: 81° 59′).—The river flows over granitic gneiss, and the channel and parts of the bank are covered by sandy alluvium. Exposures of the gneiss are frequent on the bed of the river near the banks. The rock which is exposed on both banks of the river in the form of steep sided hill masses consists of coarse porphyritic, granitic gnessies traversed by occasional quartz veins. Quartzites have been mapped on the top of some of the plateaux and in the valley of the river north of the dam-sites The gneiss is jointed: horizontally disposed open joints especially in the upper reaches of the hill slopes, are quite prolific. Detailed investigation of these is necessary before accepting any of the sites.

Hasdo river.

Ghamota dam-site (64 J/10 and 11; 22° 29′:82° 40′).—It is located in a deep gorge of the Hasdo river. Archæan rocks are exposed on both banks but the river bed is covered with alluvium and full of 'quick-sands'. The reservoir basin is underlain by the Gondwana formation (Talchirs). The condition and behaviour of the basement and the possibilities of leakage through the Talchirs require to be investigated.

Jonk river.

Uprani dam-site (64 K/10; 21° 35′:82° 32′).—The Jonk river has cut a deep canyon, about two miles long, very near the mouth of the river. The river bed is full of rock exposures and the banks are precipitous. The exposed rocks are hard and tough quartzites, conglomerates and indurated sandstones of the Cuddapah formation. The beds are horizontal to gently dipping (maximum 10°) to N.N.E. and the topography is very good for a dam. Exposed rocks will be sound enough as regards their bearing strength for a masonry or concrete dam; but the possible existence of a fault along the river bed at the dam-site and the joints or fissures in the strata should be fully investigated.

Narbada river.

Jhapni dam-site (55 M/16; 23° 00′:79° 56′).—The river here is narrowed by Deccan trap hills on both sides. There are outcrops of amygdaloidal basalt in the river bed at some points, but a cover of older alluvium of irregular thickness fringing the banks is a regular feature of the topography. The foundations of dam are sound, but large scale geological mapping is recommended to find out whether any inconvenient joints or fissures or other weak zones exist in the Deccan trap.

Malikheri dam-site (55 F/NE; 22° 45′:77° 45′).—Both banks are alluvium covered to a great length and there are no rock exposures till the Vindhyan sandstone escapements are reached on the north bank above the possible top of the dam. The abutments are flat, and the site does not appear to be satisfactory.

Hoshangabad dam-site (55 F/6E; 22° 45′:77° 43′).—The left abutment bank is east of Hoshangabad Circuit House and the right abutment is in the escarpments beyond Joshipur (Bhopal State). The right abutment consists of high hills of steeply dipping Vindhyan sandstone; but this is about two miles inland from the river. The river banks are covered by exposed thickness of 40 to 70 feet of Older Alluvium. On the left bank the crest of the dam will reach almost the peak point of the highest available contour in the alluvium. The river exposes a section showing about 60 feet of alluvium, underlain by Bagra conglomerates. The junction between the Bagras and the Vindhyans is nowhere exposed; but it is likely that the line of junction is hidden under the river, at least is covered by the alluvium in the river valley. Detailed geological investigation will be necessary before deciding on the feasibility of the site. Topographically it is not a very promising site.

Tawa river.

Chamardal dam-site (55 F/14; 22° 35′:77° 59′).—The gorge is narrow with steep hills forming the banks of the Tawa river. The dam-site is about one-third of a mile north-east of Chamardal. The river bed is sand covered to an unknown depth and quicksands are quite common. Hard and compact sedimentary rocks consisting of conglomerates alternating with some sandstone and shale form the hill masses. The rock exposed at the dam-site is conglomerate which is very tough, and the cementing material consists of fine sand and clay. Some limestone beds are also exposed near the railway bridge on the Tawa river, about one mile north of the dam-site.

Indravati river, Barsur and Kondamosam dam-sites.

In the month of December 1947, Mr. M. S. Balasundaram visited two dam-sites on the Indravati river in Bastar State in the company of the officials of the Central Waterpower, Irrigation and Navigation Commission.

Barsur dam.

The *Barsur dam* will be located three miles south-west of Barsur (65 E/8; 19° 9′ : 81° 23′) and will be about 25 miles from Bantewara (65 F/5), a fairly important town. At this site the width of the river is about 2,000 feet. The rocks found in the bed of the Indravati river near the dam-site belong to the Archæan complex and are mainly composed of fresh and hard, foliated gneiss striking N.W.-S.E. dipping upstream. Jointing parallel to a S.S.W.-N.N.E. direction is common but not very prominent. As far as the bed of the river is concerned it can be safely said that the foundation rock (gneiss) is hard and impervious and will provide excellent foundation for a dam. Mr. Balasundaram mentions that material for coarse aggregate is easily and abundantly available from the gneiss and the quartzite outcrops near by. He adds that there are possibilities of locating suitable limestone deposits in the calcareous series of the Cuddapah formation near Jagdalpur (65 I/4; 19° 5′ : 82° 4′) for the manufacture of cement.

Kondamosam dam.

The *Kondamosam dam* is situated seven miles south-west of Bhopalpatnam town (65 B/5; 18° 52′:80° 23′) which is connected by road to Jagdalpur, a distance of 131 miles. The length of the dam would be 6,000 feet and the height of the dam up to the 450 feet contour will be 160 feet. The reservoir thus created will submerge the Bhopalpatnam town. The dam running north and south will be founded entirely on Cuddapah shales which dip 38°-50° towards the S.S.W. There are two sets of joints, due to which the shales on weathering break into rectangular pieces and rarely into rhomboidal pieces. In some places the shales also show vertical cleavage and schistosity. The joints present in the shales exhibit a tendency to close at comparatively shallow depths. Mr. Balasundaram apprehends that the overburden in the bed of the river is likely to be thick. He advises extensive drilling to find out the sub-surface structure, disposition of beds, presence of joints, cracks, soft zones, faults, etc. Finally he considers that the conditions obtaining at Kondamosam appear to be to a large extent similar to the Watts Bar dam of the Tennessee Valley, and suggests that a concrete gravity structure with spillway section and earthen embankments, as obtains in the Watts Bar dam, would be quite suitable at Kondamosam. The quartzite hills close by would provide good material for coarse aggregate. The limestone occurring four miles E. 30° N. of the dam-site should be investigated to find out whether it is suitable for the manufacture of cement.

MADRAS

Tungabhadra Project, Bellary district, Madras.

At the request of the Chief Engineer, Special, Public Works Department, Madras, Mr. M. S. Venkatram paid a brief visit to the Tungabhadra dam-site, Hospet, in the third week of May 1948, to inspect the foundation excavation so far carried out along the dam alignment on the Madras side.

The excavations have gone down to varying depths in the different sections of the dam alignment. The rocks exposed are mainly epidiorites with occasional pegmatite dykes. Mr. Venkatram advised the engineers regarding the suitability of the rock, and suggested the depth to which excavation should be taken down further in places to reach hard, sound rocks.

Kistna-Pennar Project, Kurnool district, Madras.

In response to a request from the Superintending Engineer, P.W.D., Madras Circle, Mr. Venkatram examined two sites for a proposed dam across the Kistna (Krishna) river near Siddeswaram (56 L/8; 16° 2′:78° 20′). However, owing to unsettled political conditions he could not examine the western abutment hills lying within the Hyderabad territory.

The proposed dam near Siddeswaram will be a gravity dam about 120 feet high and a little over 2,500 feet long. The approximate capacity of the reservoir is estimated to be 120 thousand million cubic feet.

Dam-site I.—The rocks exposed near the site are quartzites overlying limestones and associated traps belonging to the Cuddapah system. These appear to incline towards the upstream side. Two bore-holes have been sunk in the bed of the river and the core recovery of hard rocks (cherty limestone and trap) from these holes is disappointing. About two furlongs further upstream there is a promising narrow band of quartzite running right across the river. The position for a trial bore in this band of hard rocks has been shown to the engineers. It has also been recommended that a series of bore-holes be sunk at intervals not less than 300 feet apart both in the bed of the river as well as in the abutments.

Dam-site II.—This is situated about three and half miles E.N.E. of Siddeswaram and on the downstream side. Here the river is comparatively narrow, but unfortunately it cuts through a highly jointed ferruginous quartzite with interbanded beds of conglomeratic breccia. The site is not very promising.

EAST PUNJAB

Dochi dam-site Ashni river, Simla Hills, East Punjab.

In compliance with a request from the Chief Engineer, P.W.D. Patiala and East Punjab States Union, Mr. P. C. D. Hazra examined in greater detail the Dochi dam-site, power tunnel alignment and appurtenant works. The project was visited[1] earlier by Dr. J. B. Auden and Mr. K. Balu in 1946 and 1947 respectively. Mr. Hazra paid three short visits to the area in May and June, 1948, during the periods when it was also inspected by Dr. J. L. Savage, Consulting Engineer from U.S.A.

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[1] *Rec. Geol. Surv. Ind.*, General Report for 1947, 81, Pt. 1, pp. 118 and 119 (1949).

The rocks at the dam-site, consisting of quartzites, quartz-conglomerates and slates, dip upstream, *i.e.*, north-east to N.N.E., at an average angle of about 45°. Since the upper reaches of a straight gravity dam founded on quartzites would pass into slates, an arch dam with variable radii has been finally decided upon, so that the wings of the dam could be confined within the same quartzite members throughout. A preliminary design for a much higher dam, *viz.*, 575 feet instead of 434 feet in height at the site recommended by Dr. Auden is being prepared by Messrs. International Engineering Co., Denver, Colorado, U.S.A. As a result of later analysis the engineers discovered that it would be rather expensive to construct a dam at the proposed site, as the right wing becomes unnecessarily long (as compared with the left wing), thus involving a greater amount of stripping to make rock-contours normal to the radius. This wing could be appreciably shortened, resulting in great economy, if the axis could be removed slightly upstream keeping the left wing more or less fixed. The engineers wanted to know if this removal of axis is feasible from geological considerations. Mr. Hazra warned them that a slight removal of the axis upstream would mean that the right abutment of dam would come to rest on terrace gravels and slipped materials. It was for this reason that Dr. Auden originally recommended a site slightly lower down. Mr. Hazra emphasised that unless the soundness of the terrace, now covered by river gravels and slipped materials, is assured after proper geological exploration, it would not be advisable to shift the right wing of the dam upstream, as proposed, since the pre-requisite condition of an arch dam is a pair of strong abutments. Moreover, shifting of the axis would mean that the right wing of the dam would cut across the strike of various rock members including a thick band of slate which is prominently exposed in the Kandaghat—Chail road section. Accordingly, Mr. Hazra outlined an explanatory programme for the dam-site with particular reference to the right abutment.

During Mr. Hazra's subsequent visits in June 1948, he was able to re-examine the local dam geology in detail and to re-map a portion of the Ashni gorge on the scale of 1/1000 showing an arbitrary thickness of competent rocks on which the engineers could re-locate the most economic alignment for the dam after necessary exploration. As a result of detailed mapping, helped by some stripping, it was found that the thick band of slate (which would come under the right wing if it is removed upstream) pinches out at depth and along the strike. It forms the core of an overfolded syncline. The two tunnels into this slate band, which had not progressed very far, revealed that the slate, which is highly siliceous and contains numerous bands of quartzite, would be quite satisfactory for foundation purposes at depth. Therefore, the occurrence of slate in the right abutment is not so very objectionable, although it would mean a greater amount of excavation and perhaps some treatment (grouting) as well. Although the two bore-holes, which were put down in the river channel, proved that the dam would rest on hard quartzites and quartz-conglomerates, the exploratory work in the right abutment had not sufficiently progressed to prove its soundness and warrant the advisability of removing the right wing of the dam slightly upstream on the terrace now occupied by river gravels and slip materials. Therefore, Mr. Hazra advised the engineers to proceed with exploratory work until a definite conclusion could be drawn.

Power tunnel alignment, Dochi dam Project.

As the power available at the Dochi dam is too small, it has been decided to conduct the water from the projected reservoir by means of a six-mile long tunnel, located in the left bank of the Ashni gorge, to penstocks overlooking Ghaura (30° 54′ : 77° 13′), thereby creating a nett head of 1,000 feet and generating about four times more power than would be possible at the dam. The tunnel will be aligned approximately in a N.N.W.-S.S.E. direction and its finished diameter after lining will be about eight feet. On account of unfavourable topography no alternative alignment is possible.

Mr. Hazra reports that due to lack of a large scale map covering the tunnel area, no detailed survey was possible for the entire lay-out. He, however, observes that the location of the intake in Poash *nala*, above its confluence with the Ashni river, is satisfactory, as the Jaunsar quartzites would provide a good foundation for gates and tresh-racks. Likewise, the foundation conditions for the surge-chamber and exit near Bhosar (30° 54′ 25″ : 77° 13′) appear satisfactory. Here the Simla slates and phyllites with interbedded quartzites are seen dipping into the hill, a desirable feature from the point of stability of the slopes which would carry heavy, steel penstocks. The power house can also be founded on hard Simla slates after necessary excavation.

The tunnel according to the published map[1] of Drs. W. D. West and G. E. Pilgrim would successively intersect the Jaunsars, Blainis and Simla slates. It would also cut through a major thrust (Jaunsar), but the tunnel may be regarded as safe, since there is no likelihood of recurrence of movement along this tectonic plane. The regional dip of the rocks is north-east to E.N.E. at 30°—50°, but local variations of dip and strike are common. Due to these reasons and because the bearing of the tunnel is not normal to the regional strike, the amount of overbreak will be large, thus raising the volume of concrete required for lining the tunnel. Minor water trouble would be met when the tunnel crosses synclines and crush zones, which may need special treatment. Whilst it is not possible to predict the exact geological conditions at tunnel grade from surface evidence alone, which is poor in places due to vegetation and soil capping, Mr. Hazra in his report has given a broad geological picture in tabular form showing respective thickness of strata intersected and conditions likely to be encountered for the benefit of the engineers, so that they may be equipped with proper machinery and accessories to deal quickly with special situations.

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[1] *Mem. Geol. Surv. Ind.*, LIII, (1928).

Materials for construction, Dochi dam project.

During his visit to the Dochi dam-site in June 1948, Mr. P. C. D. Hazra also investigated the sources of materials for construction. He reports that there are no large deposits of natural, well graded aggregate, coarse or fine, near the dam-site, which could meet the demand for concrete. Moreover, the gravel deposits obtainable from the bed of the Ashni river or terraces are not suitable due to excessive proportion of slate and slaty rocks. As such, Mr. Hazra advises that quartzites and some of the quartz-conglomerates belonging to the Jaunsar series, which are locally available, should be tested for the purpose.

Sand and fine aggregates are also not available in any quantity from the river bed or terraces. Therefore, resort should be taken to crushing quartzites occurring near the dam-site to produce fine aggregates and sand. At the Chief Engineer's request Mr. Hazra examined the 'sand' deposits near Salogra (30° 56′ : 77° 08′), which are extensively tapped for building houses in the neighbourhood. The 'sand' is derived from the soft or crumbling variety of Krol Sandstone. As the sand appears ungraded and is heterogenous in composition Mr. Hazra apprehends that it may not be suitable for cement concrete. He, however, recommends that it should be properly tested in a laboratory equipped for this purpose.

The requisite quantity of cement would be available from the Bhupendra Cement Works, Surajpur, situated at a distance of about forty miles from the dam-site. A few deposits of limestone occurring nearer the dam-site have been tested as regards their suitability for the manufacture of cement locally, but so far no suitable deposits have been found.

UNITED PROVINCES

The Sarju dam-site, Almora district, United Provinces.

Dr. M. R. Sahni investigated two alternative sites for a 650 feet high dam in the gorge of the Sarju river, both situated within a short distance of each other, to the north-east of the village Singda (29° 30′ : 80° 8′) on sheet 62 C/NW.

The object of the proposed dam is to conserve sufficient water to maintain a discharge of 9,500 cusecs through the Sarda canal and to enable the Khatima Power House, Sarda Hydel Project, to generate 41,400 kw. continually.

The geological succession in the gorge consists of gneisses associated with intercalatory bands of schists of varying thickness. The foliation dips at the first dam-site are 75° to 80° downstream. At the second site massive gneisses dip about 80° to the southwest (downstream). Dr. Sahni considers both the sites feasible but prefers the latter where the rocks are more massive and tightly jointed.

Bhatta dam-site, Mussoorie.

Dr. M. R. Sahni examined a dam-site situated at 560:000 in sheet 53 J/3 and square Kk, in the 8″ Guide Map, a short distance to the west of Bhatta village. The investigation was carried out at the request of the Administrator, City Board, Mussoorie, in connection with the Mussoorie-Dehra Dun Hydro-Electric Works.

The alignment that was proposed by the P.W.D. Engineers is in two sections. One of the sections, about 500 feet in length, commences south-east of B. P. No. 2, immediately south of the cart track leading to the intake reservoir, and runs approximately N.W.-S.E. as far as the right bank of the Kiarkuli Nadi. The other section, a little over 700 feet long, runs almost due east-west. The combined length of the two sections of the alignment is about 1,200 feet. Examination of the area a few hundred feet downstream appears to indicate that a much shorter alignment might be possible below the junction of the two sections of the alignment already proposed. The new alignment also appears to be along sounder rock than the one already surveyed. The geological section here, as investigated by

Dr. Auden, is composed of three different members of the Krol D Sub-stage as follows:—

(a) Bands of moderately compact dolomite,

(b) Predominating crumbly black dolomite, almost in the condition of "bajri",

(c) Soft bleaching shales.

The dam-site proposed by the P.W.D. is hinged upon the softer members of the above section. One of the advantages of the alignment now suggested by Dr. Sahni over the previous one is that it would traverse the most stable member of the Krols exposed here, namely, the compact dolomite. These massive dolomites are exposed more or less continuously along the entire length of the alignment, and therefore no extensive pitting would be necessary; however, that is a minor point. Another, possibly greater, advantage of this site is that the alignment would be shorter by about 300 feet than the one already surveyed. When it is realised that the latter is about 1,200 feet long, the saving in cost is manifest. An important point, however, is to determine whether the storage capacity of the new reservoir compares favourably with that of the other. This can only be done by actual detailed survey and it is suggested that the same might be carried out by the P. W. D., before any final action is taken in regard to the other alignment.

Dr. Sahni is, however, of the view that neither of the two sites is likely to be economic considering the size of the proposed dam and the comparatively small storage capacities of the reservoirs. It is also by no means certain that a more stable site near Mussoorie cannot be found for a dam of the size proposed, impounding at the same time a much larger quantity of water. In regard to this the Executive Engineer agreed with Dr. Sahni. The survey of an alternative site is therefore not only desirable but necessary before any site is finally selected.

Dr. Sahni also makes another alternative proposal. He suggests that a smaller dam might be erected at a suitable location upstream of the sites already considered, and the supply discharged by pipes to some place near the position of the existing storage reservoir, where a second Power Station might be located. The same supply could be discharged into the existing reservoirs and utilised, as before, by the present Power House. Further survey is, of course, necessary to determine if this is feasible.

Briefly, in Dr. Sahni's opinion,—

(1) The dam alignment already surveyed does not appear to be the one most suitable.

(2) An alternative alignment, a few hundred feet downstream of the above is suggested. It follows harder rock and is shorter by about 300 feet.

(3) However, the relative storage capacities of the two reservoirs should be determined before either site is finally accepted.

(4) It is likely that a site much better than either of the above two might be found at a convenient distance, since the area around Mussoorie has not been explored from that point of view.

(5) Finally, if one of the biggest schemes proposed for the U.P. is likely to mature in the near future, the need for this dam for generation of power will not arise.

Pindar Valley Projects, Garhwal district, United Provinces.

At the request of the Chief Engineer, P. W. D., Irrigation Development, U. P., Mr. S. P. Nautiyal carried out a reconnaissance survey for suitable dam-sites on the Pindar river in the Garhwal district, in January, 1947. Subsequently in June 1947, two of the dam-sites were investigated in detail. The Pindar river issues from the Pindari glacier, and after flowing through the Almora and Garhwal districts joins the Alakananda river at Karnaprayag (53 N/3; 30° 15′:79° 13′).

The average slope of the Pindar river between Nandkeshari (53 N/12; 30° 3′:79° 33′) and Karnaprayag, a distance of 33 river miles, is 50 feet per mile yielding a gross head of nearly 1,680 feet. The valley is narrow and does not afford much storage, but is eminently suitable for the development of cheap power projects. The average winter discharge is about 700—800 cusecs, but it increases to about 2,000 cusecs as a result of melting snows during summer. The present proposal of the Irrigation Engineers is to utilize the gross head in a single storage or in several stages.

Regional geology.

The regional geology of the Pindar valley is known from the works of Auden and Heim and Gansser. The normal sequence of the rock formations has been inverted by thrusts during the uplift of the Himalaya during the early

Tertiary period. The tectonic sequence met in the area is as follows :—

Gneisses and schists with diorite intrusives	Tharali Thrust Unit.
. . . .	Thrust
Intrusion of basic rock . . Quartzites, limestones and slates.	Garhwal series of Auden; Calc. Tejam zone of Heim and Gansser.

The Pindar gorge between Karnaprayag and up to a place two miles downstream of Narayanbagar presents topographically many suitable sites for the high concrete dams. The rocks in the canyon walls at the proposed sites are sound, although slightly weathered on the surface. The gorge upstream of Narayanbagar is wider and the rocks in the abutments are hidden under a thick cover of talus. The various dam-sites studied by Mr. Nautiyal are discussed below separately.

Padali dam-site, Pindar Valley Project.

The Padali dam-site is located about one and half miles upstream of Karnaprayag. The river is about 134 feet wide and the crest length for a 300-foot high dam will be about 330 feet. A still narrower cross-section exists only 100 feet upstream of this point. The dam-site is located on basic rocks of the Garhwal series. In Mr. Nautiyal's opinion the fresh, basic rocks will provide a satisfactory foundation for the high, concrete dam. An arch dam appears most suitable, as the rocks in the abutments are massive and less jointed.

No major weakness has been detected from surface examination, except a few sheeted zones. A concealed fault running parallel to the gorge has, however, been established, since it has laterally displaced the sheeted zones on the abutments. This fault does not appear to be a threat to the feasibility of the site, but its nature and extension should be determined by drilling in case any special treatment is necessary. If the cost of treatment of fault and sheeted zones on exploration by tunnels and bore-holes proves prohibitive, the dam-site will have to be abandoned. Suitable quartzites for concrete aggregate are available within short haul of the dam-site. Natural sand is not available and quartzites will have to be crushed for the purpose.

Noli dam-site, Pindar Valley Project.

The Noli dam-site is located about five miles upstream of the Padali dam-site at 30° 12′:79° 19′. The gorge formed by the Pindar river at this point is very constricted and is hardly 150 feet wide. Massive quartzites and quartz-schists comprising the rocks of the area are capable of supporting the weight of a high concrete structure. The rocks dip 60° upstream and the foliation is conformable with the dip. Jointing is pronounced and the sets of joints which are parallel to the canyon have to be carefully grouted or else they will promote leakage under the dam foundation. No faults of any significance have been observed. Mr. Nautiyal has recommended several diamond drill holes in the river bed, as well as into the flanks for exploration. Drifts of suitable lengths in both the abutments will also be necessary.

The massive quartzites present near the dam-site will provide requisite aggregates for concrete on crushing. Supplies of sand from the river bed will be limited and will have to be supplemented by crushing the available quartzites.

Baghauli dam-site, Pindar Valley Project.

The Baghauli dam-site is located in the Pindar gorge about two and half miles upstream of the Noli dam-site at 30° 15′: 79° 19′. The gorge is again very constricted and the canyon walls are almost vertical to an elevation of about 500 feet above the river bed. The width of the river bed is about 180 feet and the top of the gorge at 500 feet elevation is nearly 440 feet. Mr. Nautiyal considers that a concrete dam of any feasible height may be built here.

The dam-site is located on the massive quartzite-rocks of the Garhwal series. The rocks dip 55° upstream and are much jointed. At least three sets of joints can be made out. Those dipping downstream will require careful study and grouting to prevent leakage. Narrow zones of sheared quartzites are seen on the right abutment above the water-level, otherwise the rocks are free from any defects.

The site is simple and does not require much exploration, but Mr. Nautiyal has recommended a few bore-holes and drifts to ascertain the depth of overburden in the river bed and the nature and extension of joints, etc.

Nalgaon dam-site, Pindar Valley Project.

The Nalgaon dam-site is located about one mile upstream of the Nalgaon suspension bridge across the Pindar river. The rocks exposed are massive quartzites of the Garhwal series dipping upstream at 50°-60°. The geological conditions are identical with those of the Baghauli dam-site. The site is feasible for a high concrete structure.

Nandkeshari dam-site, Pindar Valley Project.

The Nandkeshari dam-site is located just upstream of the suspension bridge near Nandkeshari (53 N/12; 30° 3′:79° 33′). The gorge is narrow and about 80 feet deep. A flat old terrace of the Pindar river on the right bank about 80 feet above the river level limits the height of the structure to about 70 feet. The rock exposed at the dam-site consists of gneissose granite of the Tharali Thrust Unit, which has been folded into a shallow synclinal structure The dam-site is located on the northern limb of the fold. No other local flexures or contortions are found in the rocks. The rocks are highly foliated and foliation planes or pseudo-bedding dip downstream at 40°. Joints are few and are open on the surface, but are likely to get tight at depth.

In Mr. Nautiyal's opinion the dam-site is suitable for a low diversion concrete dam of about 80 feet in height. For a higher dam, removal of overburden on the right bank and the expected deep weathering underneath are questions involving expense and requiring careful exploration.

Flume alignment, Pinder Valley Project.

At the request of the Chief Engineer, P. W. D, Irrigation Development, U.P., Mr. S. P. Nautiyal examined the flume alignment to conduct the water of the Pindar river from Nandkeshari (30° 3′: 79° 33′) to Karnaprayag (30° 15′: 79° 13′). Due to bad slips on the left bank along the valley, Mr. Nautiyal recommends that the flume should be kept on the right bank, where hill-sides appear more stable. The wide, boulder-filled courses of the transverse *nalas* on the right side of the Pindar gorge will have to be suitably negotiated, as the mountain torrents during monsoon bring down a large amount of boulders and trees. It may be advantageous to tunnel through the spurs rather than go round them and thereby save extra length of flume.

Lalitpur dam project, Shahzad nadi, Jhansi district, United Provinces.

In compliance with the request of the Chief Engineer, Eastern Canals, P. W. D., U.P., Mr. P. C. D. Hazra investigated during May, 1948, the Lalitpur dam-site (54 L/6; 24° 40′ 35″:78° 25′) on the Shahzad nadi, Jhansi district, United Provinces. An eastern dam using the local top-soil is under construction. The crest length of the dam would be about two miles approximately, and the height about 60 feet. Storage will be about 80,000 A.F., which would supplement the irrigation facilities on the Betwa Canal system.

The country is practically flat and comprises part of the Vindhyan tableland. The river banks are low, varying from 15 to 25 feet in height. The rocks encountered in the vicinity of the dam-site are Bundelkhand granite, quartzite and a subordinate amount of quartz-schists. Vein quartz is common and trap dykes are occasionally met. The rocks are prominently traversed by joints, the direction of master joints appearing to be 55°—235°. The dip and strike directions are rather uncertain due to the remarkably rolling disposition of the formations. The average direction of dip appears to be north to N.N.E. at low angles. The quartz-schist band in the left abutment, however, dips almost vertically, striking W.S.W.-E.N.E.

Due to flat topography the rocks on the either banks are concealed under a mantle of alluvium and ferruginous soil (regolith) varying in thickness from 0 to 10 feet. The depth of weathering is shallow, but at several points along the alignment it has been found to exceed 15 feet, *e.g.*, no rock was encountered in the middle of the river channel although excavation exceeded 15 feet.

Although the head of water would not be excessive, Mr. Hazra advised that in order to prevent undue leakage through the foundation, a concrete, masonry or puddle core should be provided. He was later informed that the engineers had already provided a masonry core in the design, but it would be replaced by a rolled earth core if good rock was not met after excavation up to 10 to 12 feet. The section of dam when resting on good soil (impervious) would be constructed without any core. Mr. Hazra recommended that borrow materials to be used in the construction should be tested in a soil mechanics laboratory. So far no such tests had been carried out.

COMMUNICATIONS

ASSAM

Garo Hills district, Assam.

Mr. B. Lasker examined the railway alignment from Damra (25° 56′:90° 47′) to Baghmara (25° 11′:90° 39′) in the Garo Hills district of Assam. He also examined the mineral occurrences along the proposed alignment. From the northern fringe of the Garo Hills district near Damra in Goalpara district, the alignment extends southward into the heart of the Garo Hills, *via* Darugiri (25° 37′:90° 47′)—Jangkhre Aggrengithim (25° 25′:90° 46′) (in Darranggiri coalfield), thence to Siju Songmong (25° 21′:90° 42′) and onwards to Baghmara in the vicinity of the plains of Mymensingh. Mr. Laskar observed that the alignment from the vicinity of Damra hills runs over the northern fringe of the Daranggiri coalfield and is mostly on the Archaean granitic gneisses and granulites, which are traversed by younger granite intrusions, veins of pegmatites, and dykes of dolerite. Intercalatory bands of epidiorites are also noticed in association with these rocks. Minor patchy outliers of basal beds of the Tura Sandstone are found on the Archaeans. In the Daranggiri coalfield, the alignment mostly runs over the gently dipping beds of sandstone alternating with fairly compact lithomargic shale bands of the Tura stage. From the Daranggiri coalfield the alignment proceeds southward over granitic gneisses, granulites and granular quartzites with the intrusives and intercalatory bands of rocks similar to those noticed along the earlier part of the alignment. The Archaean rocks are plicated, and are well jointed both in horizontal and vertical directions as seen along the alignment, exposed in the deep narrow gorge of the Simsang. About 600 feet to the north-east of the village Siju Songmong the alignment along the western bank of the Simsang river encounters the beds of the Tura Stage again abutting against the granitic gneisses. At this locality, the older gneisses have been upturned and overthrust together with the younger Tertiary formations overlying them, which have been sheared and partially eroded away. The eastern part of the village is on the limestone and the western part on the sandstone. After a short run of about 600 feet on the alternations of sandstone and shale of the Tura stage in the close vicinity of the village, the alignment runs over the exposed beds of Nummulitic limestone occurring as an anticline with one limb dipping N. 15° E. at 70° and the other dipping S. 28° W. at 40°, as has been observed in the gorge of the Simsang to the south-east of the village Siju Artheka (25° 19′:90° 41′).

Leaving behind the exposures of the Nummulitic limestone, about 2,000 feet to W. 28° N. of Siju Artheka village and in the vicinity of the bend of the Simsang, the alignment runs along the western bank of the river over monoclinal beds, consisting of alternations of soft reddish-brown or bluish-grey carbonaceous shales and sandstones locally classed as the Siju shale stage of the Surma series, which are exposed along the alignment up to about ¼ mile south of Rewak Choklokgithim village (25° 19′: 90° 40′). The alignment south of this point enters the zone of Upper Tertiary formations. From the vicinity of the village Rewak Rongchekgiri (25° 18′:90° 40′) up to a few hundred yards to the south of Jalegiri village (25° 17′:90° 40′) the alignment is mostly over plain country with a deep mantle of alluvium. Further to the south and in the vicinity of the village Gokha (25° 16′:

90° 39′) the alignment runs on the hilly country, exposing beds of soft, massive sandstones with alternating beds of laminated grey clayey shales. Some of the sandstones have a finely pitted appearance, on account of the leaching of the calcareous contents of the sandstone. Along the scarps traversed by the alignment from Gokha to Baghmara beds of sandstones striking east-west are exposed: these have usually a dip of about 25° in a southerly direction.

The sandstones are slightly calcareous, massive, friable and current bedded. The original colour of the sandstones is greyish.

The shale beds in the vicinity of Masighat (25° 15′:90° 39′) are slightly carbonaceous, and the beds towards Masighat are more compact than those exposed in the Baghmara area.

Three bridges are proposed to be constructed on the Simsang river, one not far east of the junction of the Rongtham and Simsang, another about 200 yards north of the junction of the Simsang and the Ronding stream, and the third about a mile upstream of Siju Songmong village. All the bridge-sites have been selected at narrow parts of the river in areas of Archaean granitic gneisses or granulites. Another bridge is to be constructed over the river Rongkhai on the Archaean granitic gneisses.

The alignment is well chosen for mineral development as it passes close to the Rongrenggiri field and through the Daranggiri field. It runs across the main belt of the coal-bearing formations with excellent deposits of Nummulitic limestones overlying them. It will lead to detailed exploration of the economic minerals occurring in the Garo Hill areas hitherto inaccessible, and help towards proper utilisation of (i) coal occurring in association with the Lower Tertiary beds of the Tura stage, (ii) the sandstone and shale (if these are found suitable for the glass or ceramic industries), and (iii) the excellent deposits of limestone exposed along the belt south of the Tura Range.

BIHAR

Barwadih-Birmitrapur railway alignment, Ranchi and Palamau districts, Bihar.

At the request of the Chief Engineer (Construction) East Indian Railway, Mr. M. S. Balasundaram carried out a preliminary survey of bridge-sites, water-supply of stations, etc., along certain sections of the proposed Barwadih-Birmitrapur railway alignment which is 117·38 miles long. The track will be 5 feet 6 inches gauge. The railway will run along the Ranchi Plateau in the Ranchi and Palamau districts.

General stability between Tikra and Kolangdega.

The region between Tikra (73 B/11; 22° 29′:84° 43′) and Kolangdega (73 B/14; 22° 34′:84° 46′ 30″) will be a pusher grade of 1 in 80. The mica and chlorite-schists near the Tikra end and the granite-gneisses north of Simaria (73 B/11; 22° 29′ 45″:84° 44′ 30″) have a foliation strike ranging from E.N.E.-N.E. to W.S.W.-S.W. with a dip towards the S.S.E.-S.E. All the rock types are hard and compact except for rare patches of weathered schist and gneiss. The schists have steep dips 60°-80°. Mr. Balasundaram concludes that this area forming part of a stable land mass of the Ranchi Plateau, not reported to have been affected by the Bihar Earthquake of 1934. will prove to be quite stable for the proposed laying of the railway line. He does not consider landslips likely in the steep dipping schists, except when such rocks are highly weathered.

Viaduct near Rabutoli.

Mr. Balasundaram reports that an alignment for a more than 800 feet long viaduct near Rabutoli (73 B/14; 22° 37′:84° 47′) is underlain by granite and granite-gneiss in the south and north abutment respectively. The depression between the abutments is covered. No major structural defects were noticed in this area. Mr. Balasundaram has recommended the sinking of four bore holes to find out the depth of overburden and has suggested that the viaduct should be founded on fresh rock for safety.

Bridge-sites.

The geology of the bridge-sites mentioned below is more or less similar. The rocks met with are granite or granite-gneiss, the latter very often perphyritic with lens-shaped felspar. The Deo, Topa, Pinjra, Banki No. II and Banki No. I bridge-sites are completely covered by alluvium, whereas Banki, Marda, Khatwa, Kerahjaria *nalas* and Sankh nadi show occasional rock exposures. The flatness of the bed of the *nalas* is a feature common to all the *nalas*. Mr. M. S. Balasundaram recommends the sinking of bore holes instead of shallow pits, to gather full data regarding the thickness of overburden and advises continuance drilling at least five feet in hard rock.

The *Deo nala bridge*, 190 feet long, will consist of two spans with piers 40 feet apart. Probings in the bed of the *nala* (80 feet wide) proved the existence of six feet of sand resting on harder soil. Since the *nala* section is narrow Mr. Balasundaram considers it advisable to have incomplete (hollow) piers in the bed of the *nala*.

The bridge over the *Topa nala* will measure 137 feet and will consist of two spans, the distance between the piers being 60 feet.

Three bore holes are suggested in the bed of the *nala* which is 250 feet wide.

The *Banki nala bridge* consisting of two spans with piers at 40 feet intervals will measure 89 feet from abutment to abutment. The right and left banks reveal rotten rock and clay materials respectively. For this bridge-site Mr. Balasundaram suggests three bore holes. A fairly thick mantle of clay material occurs at the left embankment. Mr. Balasundaram observes that the entire removal of this material will be costly, consequently he advises the sinking of friction piles into the clay, or alternatively flattening the section of the embankment with slopes of 1:4 resting on clay.

The Pinjra nala is 78 feet wide and the proposed bridge will be a little longer than the width of the *nala.*

The Marda nadi is 240 feet wide, and a three span bridge is projected across it. Mr. Balasundaram has recommended that the thickness of the overburden be determined.

The Khatwa nala is 120 feet wide and the bridge would be 134 feet 6 inches long in two spans. One hole is proposed in the middle of the *nala.*

The Banki nala No. II bridge will have three spans with piers at 100 feet intervals and the bridge from abutment to abutment will measure 326 feet. In the bed of the nadi, which is 240 feet wide, three bore holes are recommended.

Two bore holes are suggested for the bridge-site across the *Kerajharia nala* which is 100 feet wide. The bridge will be 131 feet long consisting of three spans with a clear width of 40 feet between the piers. The granite-gneiss exposed in the left bank is highly weathered.

The Banki nala No. I bridge is 223 feet long with five spans, the distance between the piers being 40 feet. One bore hole is proposed in the middle of the *nala* (130 feet wide).

The bridge across the *Sankh nadi* (175 feet wide) will be 316 feet long and will be made up of seven spans with a clear width of 40 feet between the piers.

Mr. Balasundaram observes that this part of the Ranchi Plateau is quite stable, and is free from structural defects which may prove to be deleterious to the building of the proposed bridges. The underlying rocks in the fresh state are quite suitable for founding bridge piers.

The quantity of water required at Tikra (73 B/11; 22° 29′: 84° 43′) and other watering stations mentioned below will be

Water supply at the Watering Stations.

roughly 50,000 gallons per day or roughly 3 million cubic feet yearly. By a very rough calculation it may be said that even about half a square mile catchment would yield ten million cubic feet which is about three years supply. At Tikra there is only one well 32 feet deep and even this dries up in summer months. Sinking wells in the bed of the Lurgi *nala* (with five to ten feet thick of river sand and gravel) may also prove to be a failure. Two dam sites: (1) a quarter of a mile west of Simaria (73 B/11; 22° 29′ 45″:84° 44′ 30″), and (2) half a mile W.S.W. of Tikra village, across the Lurgi *nala* were investigated. A low weir appears to be quite feasible at both the above sites, but the nearness of the Tikra dam-site makes it more suitable economically.

The proposal is to improve the tank already present near Kolangdega (73 B/14; 22° 34′:84° 46′) Mr. Balasundaram outlines the following improvements: (1) building the earth bund with slopes 1:3 upstream and 1:2 downstream, (2) filling the gap at the northern end of the present bund, and (3) constructing a waste weir on the rocky exposure near the south end of the present bund. He observes that the required quantity of water for the Kolangdega railway station can be stored, but points out the necessity of a bridge just north of the railway station where water from the tank will back up.

The proposed Tutikel (73 B/14; 22° 39′:84° 46′ 20″) station will be on top of a plateau. A dug well will be a doubtful remedy. Mr. Balasundaram who examined the adjoining area is of the opinion that the narrow Deo *nala* gorge three quarters of a mile north-east of Topatoli (73 B/14; 22° 40′ 45″:84° 46′) offers an ideal site for locating a dam. The disadvantage of this reservoir is the additional cost of the pipe line and pumping that may be necessary, which contingency, however, cannot be avoided if Tutikel happens to be the watering station.

The railway engineers were surveying the depression between the villages Dahudanrtoli (73 B/9; 22° 52′ 30″:84° 40′ 30″) and Khuntitoli (73 B/9; 22° 52′:84° 40′ 20″) with a view to bund the nameless *nala* flowing between the above mentioned villages. Mr. Balasundaram advised against putting a bund here for the reason that the reservoir created would flood a portion of the railway alignment. As an alternative he examined two dam-sites: (1) half a mile north-west of Koenjali (73 B/9; 22° 51′ 20″: 84° 40′ 45″), (2) a quarter of a mile north of the proposed Palkot (73 B/9; 22° 52′ 30″:84° 39′) station. He concludes that the first site is more suitable but the pipe-line and pumping will be costly.

There are no suitable sites in the *nalas* near Ghaghra (73 A/11; 23° 16′:84° 33′ 30″) for putting a bund at a reasonable cost. The wells inside the village are more than 30 feet deep and yield a fair quantity of water. Mr. Balasundaram recommends a test well south of the Gumla-Ranchi road and north of the proposed station to determine recuperation factors during summer months. If the results are promising a few wells can be had 500 feet apart.

The idea of improving the existing Victoria Ghat tank at Lohardaga (73 A/11; 23° 26′:84° 41′) very close to the proposed Lohardaga station (E. I. Ry.) appears to be best in view of the absence of alternative sources of water supply within a reasonable distance. Mr. Balasundaram suggests: (1) a survey of the tank bed to find out the storage capacity of the tank, (2) improving and reconditioning the present waste-weir, (3) paving the earth slope facing the tank, and (4) deepening the tank bed.

Bridge-sites on the Subarnarekha river, Singhbhum district, Bihar.

In response to a request from the Superintending Engineer, Chota Nagpur Circle, Mr. M. S. Balasundaram examined four bridge-sites across the Subarnarekha river near Galudih (73 J/6; 22° 39′:86° 25′) in Singhbhum district in January, 1948. It is proposed to construct a concrete bridge across the river, placing it above the high flood level, to connect an all-weather road between Calcutta and Tatanagar. The area between Rakha Mines R. S. (73 J/6; 22° 39′:86° 22′ 30″) and Ghatsila (73 J/6; 22° 39′:86° 29′) is underlain by mica-schist and phyllite, both of which have a regional cleavage strike of N.E.-S.W. with steep (cleavage) dips towards the N.E. Hornblende-schists are seen interbedded with the mica-schists. Other rock types noted here are quartzite, epidiorite and ultrabasic rocks. The formations are disturbed by folds but singularly free from faults.

Bridge-site No. I is located about three furlongs east of Rakha Mines and 2½ miles W.N.W. of Galudih R.S. (73 J/6; 22° 39′: 86° 25′). The chloritic and siliceous bands occurring on either side of the banks have more or less the same cleavage strike (E.S.E.-W.N.W.) and dip (45°-55° N.N.E.). The east bank exposes 20 feet of rock overlain by 10-15 feet of soil capping. The west bank, 20-35 feet high, does not expose rocks in the abutment zone. The rocks are weathered at the surface, and are jointed. Mr. Balasundaram concludes that foundation conditions are suitable for the projected bridge and suggests stone pitching of the western bank to guard against the erosive action of flood waters. The approach to the bridge-site is bad and may involve appreciable filling.

Bridge-site No. II will be about 3,360 feet downstream of the Ghatsila (73 J/6; 22° 34′:86 29′) ferry. The proposed bridge running roughly east to west can be founded entirely on the quartzite which strikes across the river in the E. 10° N.-W. 10° S. direction. The dip of the quartzite is upstream (50° towards N. 10° W.). The quartzite is flaggy and it is permeated by both strike and dip joints. Mr. Balasundaram concludes that the quartzite in the foundation is quite fresh and sound. He, however, recommends:—(1) a detailed study of the joints in order to seal them completely wherever necessary, (2) protection works for the right bank of the river as well as on the banks of the two streams flowing into the river just upstream of the bridge-site, and (3) building a training wall to dissipate the impact of the flood waters on the left bank. The quartzite 100-130 yards will be sufficiently broad to accommodate the bridge, and hence the softer schists occurring upstream and downstream are expected to have very little adverse effect on the proposed bridge.

Bridge-site No. III is situated half a mile W. 30° S. of Maubhandar (73 J/6; 22° 36′ 30″:80° 27′). The alignment runs N.E.-S.W. at right angles to the general strike of the phyllitic rocks. There are more than four bands of quartzite, two of which run oblique to the river section. A repetition of quartzite bands showing opposing dips indicate folding here. The abutments can be built on hard quartzites whereas some of the bridge piers are likely to rest on softer schists. Since two rocks types of different bearing capacities are met with, Mr. Balasundaram advises unyielding abutments on solid quartzites and short spans to guard against the possibility of unequal settlement.

Bridge-site No. IV is about a quarter of a mile upstream of Mosaboni ferry crossing. The rocks found here are mainly garnetiferous mica-schists which are contorted and folded. The cleavage strike of the schists is N.W.-S.E. with steep dips towards the north-east. Schistosity and folding are more prominent than joints. The right bank is 50 feet high and has a rocky abutment, while the left bank is 30 feet in height and does not reveal any rock outcrop. The left bank is over topped during high floods. The greater part of the bed of the river towards the left bank has a thick deposit of sand. Mr. Balasundaram observes that this site may involve a good deal of excavation of overburden before bed rock is reached in the foundation.

The widths of the river at the above four bridge-sites are respectively 1,100, 1,350, 1,081, and 1,000 feet. Mr. Balasundaram points out that bridge-sites I and IV will be wholly on mica-schists and the overburden in both the cases will be appreciable. The Ghatsila and Maubhandar bridge-sites will be mostly on quartzite rocks. The former site is within a mile of the Kharagpur-Tatanagar road, while the latter has the advantage of being near the Indian Copper Corporation at Maubhandar. He finally concludes that in so far as the presence of fresh and sound rock exposures are concerned, the Ghatsila site (II), though the longest of the four bridge-sites, is the most satisfactory.

BOMBAY

Bhore ghat tunnel, G. I. P. Railway, Bombay.

Dr. B. C. Roy inspected the Bhore Ghat Tunnel No. 23 in response to an urgent request from the Chief Engineer, G.I.P. Railway, with a view to examining the feasibility of the following alternative proposals:—

(1) Widening of a part of the tunnel on the Down or East side and then branching out (near 300 feet chainage from Bombay end) with a full section 175 feet long single line tunnel. Some doubt is expressed about the existence of suitable rocks for widening operations in the length proposed to be widened. The cost is estimated at Rs. 4 lakhs.

(2) Widening of the existing tunnel on the Up or West side and then taking an altogether new full section single line diversion tunnel, 575 feet long, at an estimated cost of Rs. 9 lakhs.

Field examination shows that the tunnel (Proposal No. 1) may lie entirely in traps which are partly altered; this constitutes a loose over-burden leading to bad cover conditions for the tunnel.

Its construction is likely to be attended with grave risks in view of its location along a steep and precipitous slope subject to rock falls during the severe monsoon rains (about 200 inches during the maximum precipitation period).

The driving of the tunnel contemplated in Proposal No. 2 is feasible and is indeed a safer proposition. The tunnel will lie completely in trap, with better cover conditions, and is not likely to cause difficulties during construction.

Dr. Roy suggested a third alternative proposal for the consideration of the Railway. It envisages widening of the existing tunnel on the Up or West side, throughout the unlined portion, and then branching out (between 400 and 450 feet chainages from the Bombay end) towards the Down or East side with an 80 feet long single line tunnel. This will ensure safety and maximum economy.

ORISSA

Bridge-sites, National Highway No. 6, Mayurbhanj, Keonjhar and Bamra, Orissa.

In order to advise the Central Public Works Department on the suitability of certain bridge-sites selected by them in Mayurbhanj, Keonjhar and Bamra for the projected National Highway No. 6 (Calcutta-Bombay), six localities were investigated by Mr. G. C. Chaterji.

The Subarnarekha river near Jamsola (73 J/12; 20° 13′: 86° 43′). The bridge alignment is across a gorge of the river, where ancient quartzites with interfoliated mica-schists and hornblende-gneisses are exposed. The bridge abutments would rest on hard and tough quartzites. The site is suitable for a bridge.

The *Amaskhal,* north-east of Kunardihi (73 J/12; 22° 13′: 86° 42′). Hard and tough mica-schists are exposed. Site was considered to be suitable.

The *Kharinala* near Joshipur (73 K/1; 21° 58′:86° 05′). Two alternative sites were examined. The country rock of the area is a grey coloured, coarse to medium grained granitic gneiss which is traversed along the foliation by well banded cherty quartzite and which bears lenticular masses of hornblende-gneiss and tremolites-schist as enclaves. Site No. 1 which provides rocky abutments on both the banks should be preferable to Site No. II, about a quarter of a mile downstream, where the southern abutment may have to rest on alluvium.

The Denola, S.S.W. of Pingu (73 Q/13; 21° 48′:85° 53′). The country rock in the vicinity of the bridge-sites is pinkish grey or light grey, coarse, homoblastic granite traversed by dolerite dykes.

Topography and geology are suitable for a bridge; but road alignment should be made safe from breach at the mouth of a tributary *nala* by shifting the site away eastwards on the south bank.

The Baitarani river.—Two alternative sites were inspected near Rajnagar (21° 46′:85° 49′) and Turmunga (21° 47′:85° 49′) in sheet No. 73 G/13.

This is in the flood zone of the Baitarani river which overflows the banks during high floods. The country rock is a grey to pinkish-grey coarse grained granite-gneiss. Interlaminated masses of epidiorite and dykes of dolerite are quite frequent.

At the Rajnagar site the east bank is lower than the west which moreover is under active erosion. At the Turmunga site the banks are of even height and no erosion was noticed on any bank.

Neither of the two site is considered to be good. If the choice of either of them is unavoidable then the Turmunga site should be preferable to the Rajnagar site. Mr. Chaterji advised further investigation for a better site in the river basin east of Koinda (20° 47′:85° 49′).

The *Brahmani river*.—Six alternative alignments were marked out in the gorge near Barakot (73 G/2; 21° 32′:85° 00′). Geologically the country is underlain by ancient gneisses and schists which are traversed by epidiorites. The alignment No. 6. near the entrance into the Barakot gorge, which has the narrowest span (about 1,800 feet) with rocky basement for founding abutments and piers, is geologically sound and should be economically desirable.

Subsequently an alternative bridge-site alignment about 3,200 feet downstream of the alignment No. 6 at Barakot was examined by Mr. Chaterji in January, 1948. This site is in the open valley. The surface of the land is gently undulating; the flat bottomed river bed rests on solid bed rock, while the steep banks are cut through a superficial mantle of unconsolidated soil and alluvium.

A band of amphibolite, about 275 feet wide at the outcrop, traversing the schistose country rock, runs rectilinially across the river at the site. The compact and tough amphibolite rock provides a sound foundation; but a bridge at this site would be 300 feet longer than one on the alignment No. 6.

UNITED PROVINCES

Tunnel alignment Rudraprayag-Kedarnath motor road, Garhwal district, United Provinces.

At the request of the Executive Engineer. B. & R., Mr. S. P. Nautiyal examined on the 7th July, 1948, a tunnel alignment on the proposed Rudraprayag-Kedarnath motor road near the temples above the confluence of the Mandakini with the Alaknanda river (53 J/S.E.; 30° 17′:78° 58′).

The proposed tunnel is to be nearly 300 feet long, 20 feet wide and 26 feet high. It would be driven through the spur from the Alaknanda side of the Mandakini to save a number of temples and some valuable properties of the local *Mahant*.

Mr. Nautiyal reports that the tunnel would pass through a diabase (Bhowali-Bhimtal type) which is a dark coloured, massive, hard rock containing numerous amygdaloidal vesicles filled with epidote. It is resistant to weathering but is much jointed. The joints are open on surface, but are likely to close at depth; as such there is no danger of rock fall or slumping of the wall or roof of the tunnel due to the joints. Minor faults with gouge and sheeted zones are likely to be encountered inside the tunnel, which may need special attention and timbering during exacavation.

As fresh rock inside the proposed tunnel would not deteriorate for a long time, Mr. Nautiyal recommends that there would be no need for lining. Weak zones, such as badly crushed or fissured portions, including the tunnel entrance, should be carefully lined. To avoid any possible damage to buildings due to violent shocks produced during blasting, he suggests that the tunnel alignment should be kept as far away as possible from the *Mahant's* properties.

Railway alignment between Ahraura Road Station, Chunar and Chopan, Mirzapur district, United Provinces.

Dr. M R. Sahni carried out a detailed survey of the railway alignment proposed by the United Provinces Government between Ahraura Road station (25° 11′ 30″: 83° 01′ 30″) Chunar (25° 07′ 30″: 82° 47′ 30″) and Chopan (24° 31′: 83° 02′). The topographical sheets used for the survey were 63 P/1, 63 P/2, 63 P/6, 63 K/16, 63 L/13 and 63 O/4.

The total length of the alignment surveyed is approximately 50 miles. The area covered by the alignment is composed of different members of the Vindhyan formation[1]. Much of the ground is covered by the Dhandraul quartzite and Scarp Sandstone constituting the Upper Kaimur stage, together with considerable stretches of alluvium.

The Dhandraul quartzite with the underlying Scarp Sandstones constitute a magnificent plateau, the northern and southern terminations of which form steep and high scarps which involve considerable difficulties in negotiating. In the northern, Sukrit scarp, the lower members of the Vindhyans are entirely absent, the Scarp Sandstones being the lowermost formation exposed, in the southern Markundi scarp, some of the lower members are seen, while others are cut off by a fault which traverses the foot of the scarp.

The strike of the beds is E.-W. with low northward dips, but it changes sharply near the foot of the Markundi scarp taking an almost N.-S. orientation.

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[1] *Mem. Geol. Surv. Ind.* LXII, p. 114 (1933).

Dr. Sahni has dealt with the survey of the alignment in eight different sections as follows:—

1. Chunar to Ahraura town (25° 01′:83° 01′ 30″).
2. Ahraura Road Station to Ahraura town.
3. Ahraura town to Chhato (24° 59′:83° 02′).
4. Chhato to Sukrit (24° 55′:83° 03′) *via* Sukrit scarp.
5. Sukrit to Robertsganj (24° 42′ 30″:83° 04′).
6. Robertsganj to Chaoki (24° 37′:83° 03′) *via* Markundi pass, along the existing motor road and thence to Chopan.
7. Robertsganj to Markundi scarp (about one mile east of Markundi pass) and thence to Ghaghar *nala*, alternative to No. 6.
8. Ghaghar *nala* (24° 37′ 25″:83° 04′) to Chopan.

In Dr. Sahni's opinion no difficulty arises in the case of any of the above sections of the alignment, except in respect of the Markundi and Sukrit scarps. To negotiate the Sukrit scarp two alternative suggestions have been made:

(i) By means of two or three reversing stations with the intervening lengths of the alignment inclined at fairly steep gradients, finally reaching the top of the plateau by a deep cutting through quartzite.

(ii) The Scarp can be negotiated along certain sandstone terraces, particularly in the lower and middle reaches of the section, the alignment hugging the southern face of the scarp in a general eastward direction and emerging at the plateau beyond milestone six of the Chhato-Sukrit road. Although the dips are in general away from the scarp and therefore unfavourable, their inclination is inconsiderable and therefore would not materially affect the stability of the route.

The Markundi scarp is, however, more difficult to negotiate. In this case also Dr. Sahni suggests two alternative routes.

In the first case, the alignment could follow, more or less, the alignment of the existing Robertsganj-Chopan motor road and negotiate the scarp by means of reversing stations, as suggested for the Sukrit scarp. As in the case of the Sukrit scarp, there are terraces in the upper and middle reaches of the scarp composed mainly of scarp sandstones, but partly of the Dhandraul quartzite, which could be made use of. The dips here are favourable being northward, *i.e.* into the scarp, and are inclined at low angles. A major fault passes near the foot of the scarp but in Dr. Sahni's opinion it is not likely to affect the stability of the route.

Dr. Sahni has suggested an alternative route for negotiating the Markundi scarp if the reversing stations do not prove feasible. About one mile east of the point where the motor road begins to descend the Markundi scarp, the fault already referred to has broken its continuity and a part of the scarp has been let down by the fault. The alignment can follow this comparatively gentle descent (considering the general steepness of the scarp) on to the lower plateau, and then ride the crest of the N.E.-S.W. running spur, composed partly of sandstone and partly of Bijaigarh shales. Difficulty, however, arises near the nose of the spur which lies sandwiched between the Ghaghar *nala* and another stream to the north of it. The descent here is rather abrupt and steep, and it remains for the railway engineers to see how far suitable gradients can be maintained in this section. While the dips are low and in a favourable direction in the upper reaches of the main scarp, the terminal section of the spur is composed of softish, high dipping, sometimes almost vertical, Bijaigarh shales. However, in the case of this alternative, a bridge will have to be constructed across the Ghaghar *nala*. Hence, in Dr. Sahni's opinion, in the long run it may be found preferable to follow the existing alignment of the motor road by means of reversing stations than the alternative under consideration. Dr. Sahni has therefore suggested a joint examination of the Markundi and Sukrit scarps with the railway engineers so that the question of feasible gradients can be dealt with·

FOUNDATIONS AND BUILDING SITES

EAST PUNJAB

Diesel Power House, Simla, East Punjab.

Doubts had been raised about the safety of the Diesel Power House at Simla, and a proposal had been made to construct a new power house near the railway station to take the fourth diesel set which is necessary to boost supply of current during the summer when the hydro-electric station suffers from shortage of water. Dr. M. R. Sahni visited the Diesel Power House early in September, 1948 and recommended the sinking of three trial pits just outside the building, which had already been enlarged to house the fourth set. Dr. J. B. Auden paid another visit at the end of September after the trial pits had been dug. The Power House is situated on the north side of the Simla ridge, at an elevation of 6 380 on an outcrop of carbonaceous phyllites belonging to the Jutogh series. The surface gradient is 1:1·73. Little rock is exposed on the ridge which is covered mostly by forest soil and surface-creep material but there is an exposure of phyllites close to the Power House which dip at gentle angles S.S.E. into the hill side. Two of the trial pits have struck phyllites also dipping southwards, and evidently little or not at all displaced. A pit 24 feet in depth put down within the Power House struck phyllites, the orientation of which indicates some degree of displacement by surface creep. Dr. Auden considers that the total absence of settlement and cracking in the Power House, where two of the diesel sets have been working with complete satisfaction for 20 years since 1928, point to the fact that the foundation rock, even though not all of it strictly *in situ*, has proved an adequate support for the building. The trial pits outside the building also show that undisturbed rock occurs just below. The slight trouble which has been experienced with the third diesel set installed in 1939 is very likely due to unbalancing of the machinery, resulting in abnormal vibrations in one corner of the building. The proposed foundation block for the fourth diesel set will not exert a load of more than 0·70 ton per square foot, which is small and should provide an ample factor of safety. Within ten years Simla will receive power from the Nangal-Bhakra hydro-electric project, and Dr. Auden considers that, in view of the past satisfactory service of the existing Power House, it would be an unnecessary expense to construct a totally new building near the railway station, to house a plant which is not likely to be in operation for more than a few years.

UNITED PROVINCES

Stability of hillsides, Naini Tal, United Provinces.

In February, 1948, Dr. J. B. Auden visited the Birla Vidya Mandir (formerly Philander Smith College and later the Hallet War School) in connection with the construction of certain buildings. In 1939 Dr. A. L. Coulson had regarded the area as dangerous, and in recommendation 55 of his published report of that year he suggested that no further buildings should be allowed except under very abnormal circumstances. Dr. Auden reviewed the evidence regarding the stability of the hill side at Naini Tal very carefully in 1942 and considered that some of Dr. Coulson's conclusions were not valid. He thought that much of the trouble at the eastern end of the Sher-ka-Danda ridge was due to bad foundations on improperly compacted cut-and-fill ground. Since 1942 there has been one year

1944, with rainfall as much as 31 inches below normal, and one year, 1945, in which it was 54 inches above normal. The ground has therefore been subject to varying moisture conditions. Observations of movements between pillars in the Birla Vidya Mandir grounds show that movement was negligible between 1942 and 1944 and very small since then, though, even so, no greater than elsewhere on the Sher-ka-Danda ridge. Dr. Auden states that the interpretation of the pillar observations is difficult. Some movements are likely to indicate no more than the effects of increasing compaction of made-up ground. Other movements represent innocuous surface creep, while finally there may be movements, from an observational point of view no different from those in the second category, which imply more serious active deep-seated subsidence. In view, however, of the geologically stable condition of the eastern part of the Sher-ka-Danda ridge and of the small magnitude of the movements, Dr. Auden considers that it would be permissible to construct buildings at the places proposed, since they will be of single storey light design and in some cases will replace old heavier structures.

CONSTRUCTION MATERIALS

A. Limestone

BIHAR-NEPAL

Bhikna Thoree.

Mr. M. S. Balasundaram examined the reported occurrence of a limestone deposit near Bhikna Thoree (Bhikhna Thori) in February, 1948, to find out its suitability for the manufacture of Portland cement which may be used in the proposed Kosi dam requiring approximately two million tons of cement.

The outer hills of the Himalayas near Bhikhna Thori (72 A/11; 27° 20′ 30″: 84° 37′) are composed of Tertiary rocks. The Someswar range which was examined in greater detail, is made up of calcareous sandstone and shale with thin bands of arenaceous limestone. A few specimens collected from this range were analysed for their carbonate content which is very low, the bulk of the rock containing more than 50 per cent. insolubles. Hence Mr. Balasundaram is of the opinion that the material is unsuitable for the manufacture of Portland cement. The calcareous tufa found in the Someswar range about three miles N. 80° E. of Maguraha (72 A/11; 27° 18′: 84° 32′) appears to be fairly good on analysis. Unfortunately this is a minor patch limited in width and extent and cannot be seriously considered as a source of raw material for the manufacture of the large quantity of cement required for the Kosi dam.

MADRAS

Cherla limestones, East Godavari district, Madras.

In April, 1948, Mr. V. Subramanyam carried out a detailed investigation of the limestone deposit near Bhumanlanka (65 B/16; 18° 4′ 30″:80° 45′ 45″) about one and a half miles east of Cherla (65 B/16; 18° 4′ 40″:80° 49′ 30″) in the East Godavari district and took representative samples from the deposit for analyses in order to estimate its utility for the manufacture of cement for the Ramapadasagar dam on the Godavari near Polavaram.

There are two exposures of limestone, (i) a prominent one on the north of Bhumanlanka extending for a distance of three furlongs in a N.N.E.-S.S.W. direction and having a width of about 210 feet. This is on the right bank of the Talperu river, a tributary of the Godavari river and east of the quartzite hill east of Cherla; (ii) a small exposure on the left bank of the Talperu river and about two furlongs E.S.E. of Bhumanlanka. This exposure is seen about 350 to 400 feet in a north-south direction and for about 50 feet along the strike.

The limestone varies in colour from gray to dark (somewhat bluish) tints and is compact, fine grained and massive. Veins and stringers of calcite are generally observed in it. Laterally the limestone grades into slaty or siliceous types which contain usually some pyrite in them. The general strike of the limestone and shales on the right bank of the Talperu is N.N.E.-S.S.W. or N.E.-S.W. and the dip 40°-70° to the E.S.E. or south-east. On the left bank of the Talperu an E.-W. strike with a dip of about 70°-75° to the north or south has been observed.

Sixty-one samples from the exposure on the right bank were analysed. Thirty-three samples show less than 10 per cent. silica; twenty-eight show silica more than 20 per cent. The magnesia content is very low, being less than 2 per cent. in fifty-nine cases. The R_2O_3 content is less than 5 per cent. in 57 cases. Sixteen samples taken from the exposure on the left bank of the Talperu were all found to be highly siliceous and not suited for cement manufacture.

Taking the limestone exposure on the right bank as a whole, a reserve of 400,000 tons is estimated within a depth of 20 feet from the surface. Out of this, only one third may be taken as good limestone (containing less than 10 per cent. silica) but half of this can be taken as suitable for manufacture of cement for the Ramapadasagar Dam Project. Mr. Subramanyam has suggested some borings in the covered areas adjoining the exposures and states that the matter can be taken up further if the borings reveal more limestone. Some borings on the limestone exposures have also been suggested by him to find out the quality of the limestones at depth.

UNITED PROVINCES

Mr. F. Ahmad carried out an exploration for constructional materials in the neighbouring areas of the proposed Rihand dam.

Limestone, Mirzapur district, United Provinces.

While the marble deposit of Garia (24° 8′: 82° 58′) is suitably situated, Mr. Ahmad suggests that in order to conserve this deposit, material for making lime may be obtained from the Bichchi *nala* (24° 8′:82° 56′) deposit some one and a half miles further south. He reports that there is no really suitable building material in the area. However, it may be worthwhile working out the comparative costs of marble from the Bichchi *nala* deposit and also of bricks delivered at Rihand dam-site.

B. Other materials

CENTRAL PROVINCES

Road metal, Chanda district, Central Provinces.

Mr. S .M. Mathur carried out an investigation for road metal for (1) the first nine miles of the Chanda-Mohrli and (2) the first six miles of the Chichpalli-Kolsa forest roads in North Chanda Division.

The Chanda-Mohrli Road.—Kamthi sandstones are the only rocks available for use as road metal in this area. Quarry sites were selected at the following localities: (i) about half a mile west of Senala (20°01′:79° 20′), (ii) at the junction of the Mothaghat *nala* with the road between miles 4 and 5, (iii) near Dhorghat (20° 03′:79° 18′); (iv) just inside Warwat Reserve Forest boundary near the road between miles 6 and 7, (v) about half a mile west of mile 10 inside the forest; (vi) near Devai Govindpur Tukum (19° 58′:79° 18′) and (vii) Coup No. XXXIII.

The Chichpalli-Kolsa Road.—Road metal is not available along the first four miles. From near the culvert over Chowpan nala and beyond, good Vindhyan sandstone can be obtained quite close to the road. Stone from the quarries about a mile east of Mahadwari (20° 01′:79° 32′) has also been found suitable.

MADRAS

Road metal, Coimbatore and Malabar districts, Madras.

Mr. A. K. Belgaumi was deputed to assist the Highways Department of the Madras Government in the selection of suitable road metals, under the post-war development scheme of the Madras Government, in the districts of Coimbatore, South Malabar and North Malabar.

In this connection an average five and a half miles stretch of land was examined on either side of the following proposed highway alignments:

(1) Coimbatore—Palghat Road;
(2) Palghat—Shoranur Road;
(3) Palghat—Calicut Road;
(4) Palghat—Kollengod Road;
(5) Palghat—Alattur Road;
(6) Palghat—Para Road;
(7) Calicut—Tellichery Road.

(1) *Coimbatore-Palghat Road.*—This road runs over the highly banded and weathered gneisses, which yield poor quality metal. A basic charnockite band running nearly parallel with the road was located about half a mile to the south of the road and it has been suggested that the fresh metal may be used for the Palghat-Coimbatore road. A similar exposure of the same rock has been located within the Municipal limits of Palghat town near Nallapalli village. The basic charnockite bands are associated with highly banded biotite and hornblende-gneisses, which are traversed by thin pegmatite veins containing small octahedrons of magnetite. The gneisses are covered by laterite which can be used as surface dressing.

(2) *Palghat-Shoranur Road.*—Exposures of medium to coarse grained basic and acid charnockites, have been located along this road. The charnockites are associated with banded biotite and hornblende-gneisses. Thin pegmatite veins were observed cutting across the gneisses, which are covered with laterites. Charnockite is recommended as better metal than the banded gneisses.

A solitary band of porphyritic amphibolite was located in the river bed about a furlong south-west of Parli Railway station. Even this metal can be used in preference to the banded biotite-gneisses.

(3) *Palghat-Calicut Road.*- This road follows the general trend of the Archaean rocks which are represented by biotite-gneiss, hornblende-gneiss, hornblende-biotite-gneiss, quartz veins, thin veins of pegmatite, granitic-gneisses, and basic and acid charnockites capped at some places by thick laterite. Before the location of these rock types the Highways Department was using banded biotite-gneiss but some of the other types are better suited for this purpose.

(4) *Palghat-Kollengod Road.*--The chief rock types met with along this road can be classified into (i) composite gneisses, (ii) amphibolites, (iii) charnockites and (iv) a thin band of mica-schist. There are a few abandoned quarries along this road, which once yielded metal of good quality. The Highways Department has been advised to open up fresh quarries along the strike of the charnockites.

For about the first six miles of the road only highly banded gneiss rich in biotite are available and a solitary exposure of charnockite has been located between the 4th and the 5th milestone.

(5) *Palghat-Alattur Road.*--This road cuts granitic gneisses and charnockites, ranging from acid to basic composition. At present only the banded biotite-gneisses are being used and the working of the charnockites and granitic gneisses has been suggested.

(6) *Palghat-Para Road.*- This road runs parallel to the strike of the Archæan rocks represented by biotite-gneisses, hornblende-gneisses and amphibolites, and in a few places capped by laterite.

Hitherto only biotite-gneisses have been used as road metal; but in view of the fact that amphibolites and basic charnockites, which occur in close proximity to the gneisses yield much better material, these should be preferably used.

(7) *Calicut-Tellicherry Road.*—The chief rock types met with along this road are (i) laterites, (ii) biotite-gneisses, (iii) coarse grained charnockites, (iv) fine grained acid charnockites with thin bands of biotite and (v) dolerites.

Although much harder rocks yielding better road metal are available in abundance in the area the Engineers have been using either banded biotite-gneisses or coarse grained biotite-bearing charnockites for this road. In preference to these the use of dolerite has been suggested since it will stand wear ana tear, and also the heavy rains much better.

ORISSA

Road metal, Cuttack and Sambalpur districts, Orissa.

Mr. M. N. Deekshitulu conducted a search for road metal along the Sohella (21° 18′:83° 24′)—Nawapara (20° 48′:82° 32′) road, the Khariar road station (20° 54′: 82° 31′)—Khariar (20° 17′:82° 46′) road and the Sambalpur (21° 28′: 83° 59′)—Sason (21° 33′: 84° 02′) road in the Sambalpur district and the length of the Augul-Cuttack road in the Cuttack district between Meramundali Railway Station (20° 48′:85° 19′) and Naupatna (20° 31′:85° 49′).

The Sohella-Nawapara road is unmetalled and 74 miles in length. Rocks met with at different parts of this road consist of pink granites, basalt and dolerite, siliceous veins, sandstone, quartzite, biotite-schist, biotite-gneiss, epidiorite and garnetiferous gneisses (khondalites). Of these the more compact and tough varieties have been selected for use as road metal. Trap rock near the second milestone, two miles and two furlongs from Sohela, dolerite W.N.W. of Katapali (21° 11′:83° 15′), khondalite south of Melda (20° 56′:82° 56′) and in hillock 1219, epidiorites east of Gurujibhata (20° 50′:82° 40′) and on the ridge near Gurujihar (20° 49′:82° 40′) and pink garnites of hill 1491, and among the more important materials selected.

The road from Khariar Road station to Khariar, 48 miles in length, is unmetalled. Pink granites, granulites, quartzites, khondalites, calc-gneisses and hornblende-gneisses occur in the area. The pink granites of the hillock west of Silda (20° 50′: 82° 32′) and the hillock north-east of Padampuri (20° 50′:82° 31′); grey granulites north-east of Bhuramura (20° 38′:82° 39′); quartzites near Goniari (20° 35′:82° 37′); khondalites of the hill east of Bilanjor (20° 28′:82° 41′) and the hill east of Bindrabahel (20° 21′:82° 43′) and hornblende-gneiss, north-east of Barpadar (20° 20′:82° 44′) are the more important among the materials selected.

On the Sambalpur-Jharsaguda road porphyritic granite gneisses, dolerites, phyllites, quartzites and mica-schists are present along the length of the road between Sambalpur and Sason. The dolerite near the Buraraja hill (21° 29′:83° 59′) and the granite gneiss near Tabla (21° 31′:84° 03′) have been selected for use as road metal.

Along the length of the Augul-Cuttack road between Meramundali Railway Station and Nuapatna, medium to coarse grained gneisses, khondalites, basic rocks, charnockites, grits and conglomerates of the Mahadeva group and laterite are present. Of the important rocks selected for use as road metal are a dark basic rock, east of the Nigra river (20° 47′:85° 19′), near Meramundali, khondalites near Uparbaghlunda (20° 46′:85° 23′) and near Jharagaria (20 13′ : 85 31′), hornblende-gneiss near hill Megha (20° 40′:85° 38′) and near Krishnapur (20° 36′:85° 40′) and charnockite south of Kankalekahad (20° 37′:85° 37′).

UNITED PROVINCES

Aggregate material, Mirzapur district, United Provinces.

Mr. G. Kohli was deputed to report on the suitability and quantity of the coarse aggregate available from the Rakshi hill near Pipri (24° 11′:83° 0′), required for the Rihand Dam project. He is of the opinion, that only a small fraction of the 60 million cubic feet of aggregate required for the project would be available from this source. In the absence of a large scale map of Rakshi hill, detailed mapping for an accurate estimation of the quartzite deposit could not be undertaken. The results of his observations were submitted in his " Preliminary Note on the Coarse Aggregate from Rakshi Hill, Rihand Project ".

Road metal, Mirzapur district, United Provinces.

Mr. F. Ahmad has reported a number of dolerite dykes in sheet 63 P/3 and P/4 cutting across the proposed Hathinala-Pipri (24° 11′:83° 0′) link-road in connection with the Rihand dam. In his opinion the quantity of road metal from these dykes would be sufficient for the entire link-road.

Aggregate material, Naini Tal district, United Provinces.

The suitability of river pebbles and boulders found in the bed of the Sarda river near Banbasa (62 D/1 & 5; 28° 59′:80° 5′) for the reinforced concrete work in the Sarda (Khatima) Power House construction, was investigated by Mr. M. S. Balasundaram.

The pebbles and boulders occur as ill-sorted deposits loosely embedded in the sandy bed of the river. In size they vary from less than an inch to more than six inches across. They are mostly oval in shape and rarely spherical. In colour they are mostly whitish; different shades of grey, pinkish, greenish and dark colours being less common. The pebbles and boulders are composed of the following rock types: quartzite, banded-jasper-quartzite, quartz-granulite, quartzite-breccia, quartzitic sandstone, sandstone, dolerite, granite, gneiss, phyllite and schist. The quartzite and its varieties alone form about 80 per cent. of the pebble and boulder deposit.

Mr. Balasundaram concludes that the Banbasa aggregate consisting of several rock types is fairly clean, fresh, hard and durable with little or no porosity. He estimates that weathered sandstones and schists together total less than five per cent. of the entire deposit and hence are not expected to weaken the aggregate material. He finally adds that this heterogeneous assemblage of rock pebbles and boulders occurring in the bed of the Sarda river upstream of the Sarda Barrage is quite good either broken into chips or in the form of unbroken pebbles as aggregate material for concrete in the construction of the Sarda Power House, approximately requiring 12 lakhs cubic feet of material.

VINDHYA PRADESH

Road metal, Datia State, Vindhya Pradesh.

According to Mr. M. K. Roy Chowdhury quartzites, vein quartz and basic rocks in the Datia State can be suitably used as road metal. Some of the reef quartz near Datia railway station is quarried for ballast. Granite may be employed as aggregate in the concrete. The well jointed quartzite near Uchar (25° 52′:78° 27′), in addition to providing road metal, can also be used as grinding stone.

GROUND WATER

ASSAM

Manipur State.

Mr. T. Banerjee investigated the possibilities of augmenting the water supply of Imphal. Supplementing the present supply by digging shallow wells was considered unsuitable, as the ground water-table is only a few feet below the surface, making the water liable to surface contamination. Tube wells may provide a better solution, but a few test borings would have to be made to find out the nature and extent of the aquifers. A sandy bed is reported to occur below clay at a depth of about 100 feet from the surface, but the water has been found to be unfit for drinking. According to Mr. Banerjee, the present supply may be augmented by constructing a low dam at the existing source about 100 yards west of the water-works. Further increases of the present supply could be made by contour channels from nearby streams, but these would be naturally more expensive than construction of the dam.

WEST BENGAL

At the request of the Ministry of Education for advice regarding the prospects of obtaining a supply of 1,000,000 gallons of groundwater per day for the proposed Higher Technical Institute and its colony of 10,000 persons, and the suitability of the foundation for heavy buildings and workshops in the area around the Hijli Detention Camp (73 N/7; 22° 19′:87° 19′) in the Midnapore district, West Bengal, Mr. G. C. Chaterji visited the area for preliminary investigations in March, 1948.

Hijli, Midnapore district.

On the Kasai-Subarnarekha watershed the country around Hijli has a gently rolling surface with meandering *nalas* separating flat topped ridges and elliptical mounds. The prevailing slope of the land is towards the east. Local slopes run into the valleys of the Kasai and the Subarnarekha rivers on the north and south respectively. The average elevation of the land around Hijli (Sheet No. 73 N/7) would be about 160 feet above M.S.L. The Kasai river which is the major drainage channel of the Hijli-Kharagpur-Midnapore zone has a perennial easterly flow, about six miles north of Hijli. The difference in level between Hijli and the bed of the Kasai river would be about 70 feet. The Kasai river has been known to overflow its banks when in high flood. Many of the tributary streams and *nalas* which take their source in the uplands around Hijli and recticulate through the surrounding country also maintain a perennial flow. The Kalighat *nadi* washing the southern slopes of the uplands flows south-eastwards at a distance of about six miles south of Hijli and discharges into the Kasai about 34 miles E.S.E. Some of its tributaries, also perennial, rise in the Hijli uplands.

In the old geological surveys of this part of West Bengal two formations are demarcated as follows:—

Newer Alluvium.
Older Alluvium.

By far the greater portion of the rolling country forming the Hijli-Khargpur uplands had been mapped as older alluvium. This is, however, covered by a mantle of lateritic deposits. No outcrop of the actual Older Alluvium was traced during the hurried inspection by Mr. Chaterji. He points out that available data from logs of tubewell borings are not sufficient to depict a correct picture of the true nature of the underlying alluvium excepting indicating the granularity and a very wide guess at the compositional character of the various layers which were pierced. Thus the formational relationship between the lateritic cap and the underlying older alluvium remains obscure.

The laterite is vesicular and the exposed surfaces are permeated by widely spaced, irregular and multidirectional joints.

Water flows freely through the laterite. Some of the available borehole logs suggest that there are irregular patches of light coloured lithomargic clay at the base of the formation. Occasional intercalation of lenticular clayey or lithomargic matter in the midst of the formation is also indicated. Since however these impervious clayey and lithomargic patches are obviously not wide in extent, they do not constitute any serious barrier to the percolation of water underground. The thickness of the lateritic deposit, however, varies widely from place to place; but not known to exceed 50 feet in this zone. In the borings in the Hijli Detention Camp area (done previously by M/s. Scott and Saxby) indications are that the depth of laterite from ground level varies between 15 feet and 40 feet.

From the available bore-hole records it is seen that the Older Alluvium consists of presumably false-bedded lenticular layers of varyingly sandy and clayey deposits. In grain size the alternation ranges between extremely pervious pebble-beds to practically impervious clays. Sand beds are quite common in the succession.

Large stretches of recent river alluvium (Newer Alluvium) cover the lands to the east of the Hijli uplands, and arms of this proceed up the valleys of the Kasai and the Subarnarekha rivers along the north and the south of the watershed respectively. In the uplands only thin strips of light, sandy and loamy material are obtained along the courses of *nalas*. The river alluvium has been generally found to be a good aquifer in the uplands as well as in the valley of the Kasai, north of Khargpur near Gokulpur.

The depths of the alluvial formations and the nature of the basement on which these were deposited are unknown. Tube-well borings both at Hijli and Khargpur have pierced the Older Alluvium down to a maximum depth of 400 feet from the ground level. The Newer Alluvium was tested down to 328 feet at Gokulpur (22° 23′: 87° 18′). Nowhere was the base touched. Mr. Chaterji found that the yield of the tube-wells generally falls off seriously within three to six years in the case of those in the Older Alluvium and three to 13 years in the case of those in the Newer Alluvium after their installation. He considers it likely that this drop in the yield is due to the choking of either the strainers or the aquifer beds around the pierced zones by the deposition of sediments.

There were no working tube-wells which were deep enough to give a correct appreciation of the pressure gradients of the circulating water in the deeper reaches of the Older Alluvium.

Wells dug in the Kasai alluvium on the north have met the heavy demands of the Khargpur supply.

Mr. Chaterji recommended that it would be useful to put down at least one or two deep experimental boreholes at geographically suitable sites in the vicinity of Hijli to test the hydrological conditions of the aquifers at greater depths. The boring should be at last 500 feet deep, preferably six inches or more in diameter, and shrouded or gravel-packed.

It is not, however, possible that one tube-well would meet the entire requirement of one million gallons of water per day. Mr. Chaterji suggested that it might be necessary to put down a battery of tube-wells (five or six may be necessary) in a selected area to obtain the entire supply.

Mr. Chaterji considers that as an alternative scheme a battery of large diameter (say 25 to 30 feet) and 60 to 100 feet deep (depending on sub-surface geology) wells in the Newer Alluvium is likely to meet the demand of one million gallons of water per day without difficulty. Suitable sites for such groups of wells would be in the alluvium within one mile east of the Hijli Sub-jail, and also in the valley basin near Uparjhuli-Taljhuli (22° 19′: 87° 20′).

The quality of water tapped from tube-wells in the Hijli-Khargpur zone is stated to be suitable for domestic, locomotive and industrial purposes.

The laterite foundation is considered to be suitable for buildings and workshops. Though no serious danger to buildings is expected from future earthquakes precautionary measures in design and construction are recommended.

BIHAR

Miners' Welfare Works, Jharia Coalfield.

In connection with the Miners' Welfare Works in the Jharia coalfield area Mr. G. C. Chaterji inspected the progress of well sinking operations at Bhuli (23° 49′:86° 24′), Alagdiha (Tisra) (23° 43′:86° 27′), Tilatanr (Katras) (23° 49′:86° 17′) and Seraidhela in December, 1947.

Bhuli.—At a site previously selected by Mr. Chaterji for a 80 feet deep well, excavation had progressed about 16 feet deep in south-westerly dipping, medium grained, jointed Talchir sandstone. Already there was copious seepage of water.

Alagdiha (Tisra).—A well was being excavated at a position about 140 feet away from a site suggested by Mr. Chaterji. It had reached a depth of about 27 feet in a succession of Barakar shale and sandstone, but not far from the Barakar-Metamorphics junction. Since work had progressed so much, further deepening was advised in order to seek a possible grit or sandstone aquifer.

Tilatanr (*Katras*).—Sinking of a well had gone about 11 feet deep in an outcrop of hornblende-gneiss at a location about 317 feet away from the site actually selected by Mr. Chaterji previously. Mr. Chaterji advised that this well was not likely to yield an adequate supply, and again recommended the site which was selected.

Seraidhela.—A well was being sunk at the southern margin of a quartz-breccia bearing fault zone in southerly dipping hornblende-biotite-gneiss. There was copious seepage even when the excavations were only 24 feet deep. Since there was the possibility of the fault-breccia being shut out by the masonry lining of the well, Mr. Chaterji recommended a little shifting of the centre of the well so as to bring the fault zone near its diameter. As an alternative he suggested the driving of infiltration galleries to cut across the fault-breccia up the dip of the country rock, *i.e.*, in a northerly direction.

BOMBAY

Ahmednagar Cantonment, Bombay.

In pursuance of a request from the C.R.I.E., Poona, Dr. B. C. Roy visited three dam-sites (A, B, & C.) across the Kaprinadi in connection with the augmentation of the present water supply of the Ahmednagar Cantonment. Advice was also sought with regard to the feasibility of obtaining water by sinking deep borings from the bottom of the existing wells in the Cantonment area.

The present water supply of the Cantonment is obtained from a reservoir created by an earthen 'bund' and from some wells located in a *nala,* drawing supply from percolation from the reservoir. A 285 feet deep bore, sunk at the bottom of an existing well, did not strike water. Another boring was in progress in a nearby well during Dr. Roy's visit and other borings were under contemplation. The borings in Deccan traps are not likely to be successful in tapping good aquifers and may be discontinued.

A dam sited at B would be the longest (3,850 feet), being a wide valley with gently rising slopes, exposing thinly bedded altered traps, with thin partings of clay beds. Here maximum excavation will be needed both at flanks and river bed to reach fresh rocks for the foundation. This site should be abandoned.

The site C, about seven furlongs upstream of site B, concerns a very narrow throat, with steep right bank, where a dam 2,850 feet long and 90 feet high is proposed. A slightly pink, massive porphyritic trap, exposed at the river bed, will form suitable foundation. The flanks of the dam will be anchored against alternating vesicular and massive compact traps. An Inter-trappean clay bed, about two feet in thickness, is exposed at the right bank. The probability of any sliding of the dam foundation due to the soft clay bed, can be obviated by its removal and grouting the gap with cement concrete.

The same clay bed can be traced for some distance upstream but it is not exposed at site A (about 2½ furlongs away from site C) where it is likely to occur below the surface. Site A has also a suitable constriction, and a dam, 2,890 feet long and 70 feet high, is feasible here.

A number of shallow percussion bores were being sunk at site A; these are superfluous and will serve no useful purpose. It is advisable to put down a few core drills at sites A and C, with a view to selecting finally a suitable site for the proposed dam. Dr. Roy believes that an earth and rock-fill dam with concrete core wall may be a better and more economical proposition.

Kaira district, Bombay.

In response to a request from the Director of Agricultural Engineering, Bombay, Mr. B. G. Deshpande enquired into the possibilities of introducing tube-well irrigation in Kaira district. Barring small rocky areas to the east and north-east, the district is essentially covered by alluvium, hundreds of feet or more thick in places. The sub-soil water occurring between a depth of 25 and 75 feet is usually suitable for drinking and irrigation purposes, although brackish water is also not uncommon within that depth. According to Mr. Deshpande, good aquifers are likely to be present between 120 and 200 feet from the surface. The water at this depth is generally under sub-artesian condition and will have to be lifted by pumps.

Nasik and Poona districts, Bombay.

At the instance of the P. W. D., Bombay, Mr. B. G. Deshpande carried out the investigation of the village water supply in parts of Nasik and Poona districts. About 35 villages in Deccan trap areas were examined and sites for wells suggested. Where the sub-soil water was regarded inadequate for the needs of the villages, alternative methods of augmenting the supply, namely, construction of dams, etc., were recommended.

Mr. K. C. Channabasappa investigated the possibilities of obtaining potable water in the coastal tracts of Surat and Broach

Broach and Surat districts, Bombay.

districts. This work was undertaken at the suggestion of the Chief Engineer, P. W. D., Post War Reconstruction, Bombay. The wells in this area, usually 30-45 feet in depth, are mostly brackish, the villagers usually getting their drinking water from shallow percolation wells sunk in the bed of the tanks most of which dry up in the summer months. As the country is a coastal plain extending over a large area without any exposures of rock, it is very difficult to form an opinion about the existence of sweet water-bearing horizons, without carrying out a series of test borings. A few bores of moderate depth are known to have struck sweet water, but no authentic data are available for co-ordination.

Central Provinces and Berar.

Mr. A. K. Roy was engaged in investigating the water supply resources of the important towns and a few forest localities of C. P. & Berar. In addition, he undertook similar investigations for the Saugor University site, Saugor (23° 51′:78° 45′), C. P. and the National Newsprint and Paper Mills site at Chandni, Berar.

Amraoti, Berar.

For the Amraoti town and the camp municipality water works, it is proposed to tap underground water by means of sinking wells in the bed of the Pedhi river about six miles N.N.W. of Amraoti (25° 56′:77° 47′). This is supposed to be a cheap and feasible scheme. The Pedhi river is perennial; the river bed consists of a good thickness of porous sand, silt and lateritic material. It is expected that good underground flow, sufficient to cater for the needs of the town and the camp area would be available here. In order to ascertain the depth of the porous material, a few borings at selected sites upstream of Walgaon (21° 1′:77° 46′) have been recommended. It is suggested that wells should be sunk where the river deposits attain a maximum thickness to be ascertained by boring. Pumping test should also be made from one of the bore holes.

Akola, Berar.

The possibilities of the water supply of the Akola municipality were investigated. It was suggested that water might be pumped from the Morna river by constructing a small anicut below the confluence of Morna and Indrupa rivers, about five miles south-east of the town. A likely site for construction of an anicut was suggested. The rate of discharge of the river is not known but this should be ascertained by regular stream gaugings at selected spots.

Khamgaon, Berar.

One storage reservoir site at Antraj (20° 37′: 76° 31′) and a site for pumping water from the Bordi *nala* at Sutala (20° 38′:76° 30′) about 2½ miles north-west of the Khamgaon (20° 43′:76° 38′), have been examined. The former site has been found to be unsuitable because the foundation rock is touched at uneconomic depth, the abutments are rather unstable and the reservoir basin would be shallow. A scheme of pumping water from wells in the Bordi *nala* at Sutala was therefore recommended, and further investigations, *e.g.* the determination of the run-off of the *nala*, the thickness of the porous alluvium and pumping tests from one of the existing wells near the *nala* bed, were suggested by Mr. Roy.

Malkapur, Berar.

One storage reservoir site about 12½ miles south of Malkapur (20° 53′:76° 15′) and an anicut site upstream of Tandulwadi (76° 11′:22° 56′) as sources of water supply for the town municipality, have been investigated. The Sanglad scheme consists of constructing a dam across the Nalganga river. Water will be supplied from here by gravity. The Tandulwadi scheme is to pump water from below the confluence of Nalganga and Wagar *nalas*. Both the schemes would be costly at the initial stage because of the distance involved and expenses incurred for the construction of a dam. The Tandulwadi pumping scheme is therefore recommended. Before finalising the scheme it is necessary to determine the rate of discharge and the high flood level.

For the Chanda town water-works the following schemes were examined by Mr. A. K. Roy.

Chanda, C. P.

(a) *A storage reservoir site at Amba nala.*—The site about two miles north-east of the town is on soft and friable Kamthi sandstones, and it is considered to be unsuitable on account of possibility of leakage of water from the sides of the proposed reservoir as well as from below the dam.

(b) *Erai nala pumping site.*—The Erai nala near Neri village, is considered to have sufficient underground flow. It is suggested to sink wells here after further investigation of the thickness of the river deposits, rate of discharge, etc.

(c) *Wardha river pumping scheme.*—The Wardha river is considered to be the best source for an assured supply of water. The only hindrance is its distance (six miles) from the towns and consequent high initial cost.

Of the several schemes examined for the water supply of Chhindwara (22° 04′:78° 57′), the one of pumping from the

Kulbehara *nala* is recommended. A likely site was selected for an anicut to store water in the river to tide over the hot months. Preparation of a detailed contour plan, determination of the rate of discharge, etc., were recommended.

Seoni, C. P.

To augment the existing municipal water supply of Seoni (22° 05′:74° 33′) suggestion has been made to increase the height of the waste weir and the dam of the present storage tank by two feet. This would collect the excess water which is now being allowed to flow over the waste weir during the rains. There is scope for increasing the catchment area of the reservoir. A suggestion has been made for a detailed contour survey of the area around Bithlee (22° 6′:74° 34′) village for this purpose.

Jubbulpore, C. P.

The present sources of municipal water supply at Jubbulpore (23° 10′:79° 57′) are considered to be insufficient and it is proposed to pump water from the Narbada (Nerbudda) river. The difficulty about the Narbada river is its high flood level, which reaches a height up to 88 feet from the bed level. As a result the headworks cannot be erected on the bank of the river. A site has therefore been chosen on a ridge near Jilharighat (23° 07′:79° 56′) village east of Gwarighat on the old Jubbulpore—Nagpur Road. The site is about one furlong inland from the river at an altitude of about 1,350 feet above the M. S. L. reached by the river in 1926. The country around is underlain by Deccan trap basalts. Water will have to be taken from the river by means of a tunnel driven through hard trap from the river bed to the sump of the well to be sunk in the upland. From this sump water will be pumped to the surface, where it will be filtered and chlorinated before boosting up again for the supply of the town against a head of 150 feet.

Katni, C. P.

A site for the construction of headworks for the Katni town (23° 50′:84° 24′) waterworks has been selected on the bank of the Katni river south of the Olpherts Paint Factory. The place is upstream of the town and much higher than the H. F. L. of the river. The Katni river has sufficient surface flow and it is expected that water supply requirement of the town can be met from this stream.

Damoh, C. P.

To augment the water supply of Damoh (23° 50′:79° 57′), a proposal has been made to increase the height of the dam and the waste weir of the present municipal storage reservoir at Rajnagar. This would increase the capacity of the tank.

Saugor, C. P.

For the water supply of Saugor town (23° 51′:78° 45′) and the Cantonment area, it is proposed to impound water by constructing a dam across the Karewan *nala* at Satgarh (23° 53′:78° 39′) about six miles north-west of the town. Water will be pumped from the lake thus formed to a high level service reservoir to be situated in the town. The dam site is on hard, compact and horizontal bedded Rewa sandstones with prominent and open joints along bedding planes at intervals of a few inches to a few feet. Water contact with the slopes of these rocks, which will form the sides of the lake, is likely to leak and percolate along the bedding planes and may give rise to springs on the northern slopes of the hill range. A detailed contour map of the area should be prepared and the bedding planes of the rocks plotted on it and their relation with the basin of the proposed lake studied in detail before undertaking the construction of the dam.

Another likely source is the Bewas river which flows past about seven miles south-east of the town. Over a distance of nearly two miles downstream the Rehli road bridge the river retains a good amount of water (eight to ten feet deep) throughout the year. Apart from the surface flow, there appears to be sufficient underground flow, the catchment area being large. Details regarding the flow, etc., should be studied with a view to consider the possibility of the water supply for the town from the river as an alternative to the Satgarh scheme.

Bilaspur, C. P.

The likely source of water supply is the Arpa river flowing past the Bilaspur (22° 05′:82° 10′) town. Although the river dries up to a large extent before the onset of the summer, it continues to have a fair amount of underground flow. Wells sunk in the river bed would be able to supply the desired quantity of water for the waterworks.

Raipur, C. P.

The present municipal water supply of Raipur (21° 14′: 81° 39′) is drawn from the Kharun river, which has a sufficient flow throughout the year. Mr. Roy concludes that the same source could be tapped for additional supply. The overhauling of the existing machineries of the waterworks and distribution system is, however, necessary.

Drug, C. P.

The source of water supply for Drug (20° 1′:81° 17′) is the Sheonath river, which has a good flow of water throughout the year. It is subject to heavy floods every year, the high flood-level reaches up to the edge of the town. A site, sufficiently high above the H. F. L., has been located by Mr. A. K. Roy on the river bank for the erection of the proposed waterworks.

Gondia, C. P.

The proposed scheme for drawing water for the municipal waterworks at Gondia (21° 28′:80° 13′) by sinking wells in the bed of the Pangoli river could not prove satisfactory, as the river dries up before the advent of summer and the catchment above the point selected is inadequate. Moreover, filthy water from the town finds its way into the river, which is thus liable to pollution. Mr. Roy has, therefore, recommended that town water supply should preferably be obtained from the Bagh *nala* located about nine miles north of Gondia. The *nala* is perennial and has a good flow. There is a good site for constructing an anicut, if necessary, a short distance downstream of the bridge on the Balaghat-Gondia road. This scheme will ensure abundant water supply for the town, although it would entail relatively heavy, initial expenditure.

Balaghat, C. P.

The water supply of Balaghat (21° 48′:80° 14′) is obtained from the Wainganga, a big perennial river. A site for waterworks above the H.F.L. has been located about one and a half miles north-west of the town.

Mandla, C. P.

The source of water supply of Mandla (22° 36′:80° 22′) is the Narbada river. The intake well for the waterworks will be sunk in the bank of the river sufficiently upstream of the town to avoid pollution. The site for such a well has been located near Khairi village, from where water will be pumped into the high level service reservoir for the town supply.

Bhandara, C. P.

The municipal water supply of Bhandara (21° 10′:79° 40′) is drawn from the Wainganga river situated at a distance of about two miles from the town. The river is large and perennial. The present supply is considered to be more than the requirement of the town. The existing pumping arrangements and distribution of water need thorough overhauling to meet the increased demand.

Shegaon, Berar.

The present water supply of Shegaon (20° 48′:76° 45′) is obtained from the Man river about seven miles away from the town. The headworks consist of an anicut, a well and an infiltration gallery constructed in the river bed. Additional quantity of water can easily be tapped from this source by increasing the efficiency of the present municipal pumping arrangements.

Wardha, C. P.

Water of Wardha (20° 45′:78° 87′) is drawn from the Paunar river about four miles north-west of the town. It is filtered and chlorinated before being pumped into the overhead service reservoir. The head-works consist of a masonry anicut built on more or less horizontal hard traps, a sump and pump-well. The tail of the impounded water reaches about three miles upstream of the anicut. The existing source of supply is sufficient to cope with the increased demand. According to Mr. Roy the present pumping arrangements and distribution of water require improvement.

Hinganghat, C. P.

The municipal water supply for Hinganghat (20° 34′:78° 51′) is drawn from the Wunna river about one and a half miles from the town. The river is perennial and has enough supply to meet the requirement of Hinganghat. During the summer the inflow of water into the infiltration well is not adequate due to decreased flow. But Mr. Roy thinks that additional quantity of water could be supplied if another anicut is constructed. Certain modifications regarding the distribution system and the existing service reservoir are, however, necessary.

Buldana, Berar.

The Painganga *nala* from which the present water supply of Buldana (20° 32′:76° 14′) is drawn is a perennial stream possessing a large catchment area. The river bed consists of porous soil and is likely to have a considerable parallel flow of underground water. Water supply for the town can easily be augmented from the present source, provided proper pumping units are installed.

Allappalli, C. P.

In order to get a good quality of water for drinking and domestic purposes, it is proposed to sink tube-wells at Allappalli (19° 25′:30° 05′). But the geological conditions are entirely unfavourable for the purpose. The village stands on hard, compact crystalline rocks which are impervious. There are no prominent cracks and fissures which may hold water. Abundant supply of water is, however, available from the present dug-wells, but the quality is reported to be bad. Mr. Roy gave necessary advice as to how the quality could be improved. An alternative is to collect rain water in built up storage tanks from the roofs of the existing buildings during the monsoon and distribute it for drinking purpose.

Chauria and Sheopura, C. P.

Mr. Roy located well sites in Chauria (79° 15′:22° 3′) and Sheopura (79° 14′:22° 13′) villages which are situated on traps.

Chikalda, Berar.

A site for a storage reservoir has been selected by Mr. Roy, east of Chikalda (21° 24′:77° 20′). A dam will have to be constructed across the Brahmasat river. This will impound sufficient water for the needs of the town. A detailed contour survey of the area has been suggested. The area consists of horizontally disposed traps with prominent bedding planes and a shallow soil-cap. As far as possible open bedding planes within the reservoir should be sealed up with cement to avoid leakage.

A few well-sites have been located by Mr. Roy in the four forest villages, Ghatang (21° 27′:77° 19′), Sembadoh (21° 31′: 77° 19′) Harisal (21° 33′:77° 7′) and Tarubandha (77° 08′:21° 26′).

Nepa Mills site, Chandni, Berar.

The site for the new Nepa Mills (The National Newsprint and Paper Mills) has been located on the bank of the Tapti river, south-west of Chandni Rly. station, on the Bhusaval-Khandwa section of the G. I. P. Railway. The estimated demand of water is about ten million gallons per day. The Tapti is a big and perennial river and there should be no difficulty in getting the requisite quantity of water throughout the year. At present, details concerning the annual discharge of the river are not known, which should be determined. To facilitate pumping and also to conserve water in the river channel upstream, the construction of a low anicut has been recommended by Mr. Roy. This would tide over the difficulties in hot months, when the flow of the river is expected to be the lowest.

Saugor University Site, Saugor, C. P.

Mr. Roy investigated the sources of water supply for the Saugor University site. It is estimated that about 200,000 gallons will be required daily. The site is situated on flat traps which rise about 250 feet above the surrounding country.

The possibility of tapping underground water in the immediate vicinity of the site is, therefore, remote. Wells dug along the edge of the Saugor lake should contain sufficient water throughout the year except during the summer, when the yield is likely to fall appreciably. It has been suggested that a battery of eight wells should be sunk in a selected area along the edge of the lake which would provide the required quantity of water. The scheme is rather costly and it is apprehended that the wells may fail during the year of poor rainfall. The site is, therefore, not commendable as far as its water supply is concerned. However, a bigger scheme for the water supply of Saugor is under investigation and if it materializes the University can be supplied with requisite quantity of water from the common source.

MADRAS

Mr. V. Subramanyam carried out a hydrological survey of the Palladam *firka* in the Coimbatore district during December 1947 to February 1948.

Hydrological survey of Palladam firka, Coimbatore district.

The area of the *firka* is roughly 110 square miles lying between latitudes 10° 55′ and 11° 3′ and longitudes 77° 10′ and 77° 20′ in sheet nos. 58 E/4, F/1 and F/5. This area is an undulating country sloping from south to north, the elevation being about 1,400 feet above M. S. L. to the south and 1,000 feet to the north.

The rocks observed in the *firka* are chiefly biotite-gneiss, hornblende-schist, hornblende-biotite-schist and amphibolite intruded by charnockite, granite, pegmatite and quartz veins. The southern portion of the *firka* is chiefly composed of biotite-gneiss whereas the northern part mainly comprises hornblende-schist. Black soil is characteristic of the southern portion of the area and red soil of the northern.

There are no perennial streams or rivers in the *firka*, but there are a number of seasonal streams dissecting it. At present water supply for irrigation and domestic use is obtained from dug wells which depend for replenishment on percolation from the limited annual precipitation of 25 to 30 inches of rain.

Mr. Subramanyam reports that wells in red soil areas generally yield good water and that wells on slopes or low lying areas below black soil areas, yield brackish water. Charnockites —massive and sheeted types—occur commonly in the northern portion of the area. Where this rock is not jointed, the yield of water is very poor. Where this is jointed, it yields a fairly good supply of water. The granites are mostly jointed and these joints have been noted to persist in depth up to 70 or 80 feet below the surface and in wells put down on such jointed rocks the yield is very good. Wells on hornblende-schists intruded *lit-par-lit* by granite also yield a good supply. But wells solely on hornblende-schist or biotite-gneiss are not so good. Wells on pegmatites intruding schists or gneiss yield good quantities of water through the pegmatites if the pegmatites persist at depth.

In connection with the rural water supply scheme of the Firka Development Department, Government of Madras, geological investigation was done around 38 villages and well-sites were located.

ORISSA

Proposed new capital of Orissa, Bhubaneswar.

Mr. G. C. Chatterji examined the existing sources of water supply and the ground water conditions in the area mainly surrounded by Gobindprasad (20° 17': 85° 52'), Bharathpur (20° 17':85° 47'), Sundarpada (20° 14':85° 49') and Sisupalgarh (20° 13':85° 51') around Bhubaneswar (73 H/15 & 16; 20° 14':85° 50') to advise on the possibility of locating a suitable site for waterworks to supply 300,000 gallons of water per day for the new capital of Orissa.

The area lies close to the eastern extremity of the gently undulating erosion slope of a low flat topped ridge which runs roughly north-south and forms the local watershed west of the railway terrance. The watershed slopes gently on all sides with shallow water-courses radiating out of it. There are a number of such channels which cut up the eastern and southern slopes into alluvium covered flat bottomed valleys and run down to the level plains below. Here there are a number of rocky mounds which stand out as rolling hillocks. The maximum height attained is about 340 feet above the mean sea level. Bhubaneswar town and the village around are situated on gently undulating ground at an approximate altitude between 50 and 100 feet above M. S. L. The average annual rainfall at Bhubaneswar is about 62·35 inches.

The river Koyakhai splits into two channels about five miles north-east of Bhubaneswar. The western one, called Bhargavi, runs in an arc girdling the uplands at the foot of which the area under report is situated. This river is about two miles east of the area and flows south over alluvium. During the dry season the Bhargavi is reduced to a thin, shallow stream in the midst of winding stretches of sand; but during the rains the river swells immensely with a great rush of water that often threatens to burst the banks and inundate the surrounding countries. The banks are generally abrupt and over long stretches are artificially raised and strengthened against floods.

There is another perennial stream, the Gangua *nala*, which rises in the highlands about two miles west of Mancheswar (20° 19':85° 51') and flows in a southerly direction, roughly parallel to the Bhargavi though with a more meandering course. All the *nalas* and monsoon water courses which take their source in the western highlands run across the area under notice, and discharge their water into the Gangua. The catchment of the Gangua above Bhubaneswar covers about 18 square miles of which the major portion is densely forested country, underlain by highly permeable laterites and excellently water bearing Gondwana sandstones.

Some of these *nalas* have been dammed up for irrigation purposes by low earthen 'bunds'. The bigger ones, *e.g.*, the *nalas* rising about half a mile east of Siripur (20° 16′:85° 49′), and one about half a mile north-west of Nayapali (20° 17′: 85° 49′) respectively are represented during the dry part of the year by a string of stagnant pools or wet ground along their courses.

The stratigraphic succession in the surrounding country is as follows:—

Formation.	Rocks.	Age.
Alluvium . . .	River alluvium, deltaic deposits consisting of sand, gravel, loam clay and mud.	Recent and Sub-recent.
Laterite . . .	Vesicular ferruginous rock with sub-lateritic lithomarge and ochreous clay.	
Athgarh stage . .	Sandstones, arkose and grits with interbedded subordinate beds of shales and clays.	Upper Gondwanas.
Khondalite series	Garnet-graphite-sillimanite-schists with quartzites.	Archæan (Eastern Ghats Facies).

The sedimentary formations rest as outliers over the Archæan metamorphic rocks. The nearest exposure of the basement is at the Dhauli hill (20° 12′:85° 51′) about three miles south of Bhubaneswar.

Extensive exposures of Upper Gondwana (Athgarh) sedimentary rocks are found from near Bhubaneswar through the forests of Rampur, Nayapali, Bharathpur, Jagannathprasad to Cuttack district in the north across the Mahanadi river. They consist principally of sandstones, grits, conglomerates and minor shale beds, together with interstratified clay and ochreous materials. Movement of ground water in the arenaceous rocks is fairly free and unrestricted. Shale and clay beds (good exposures of the latter occur in Bharathpur and Jagannathprasad forests) are few and far between; they are generally gritty and moderately porous; but there are certain bands of refractory clays which are practically impervious. Sandstone partings are quite common in the argillaceous strata. The formations dip vary gently at angles of 2° to 6° towards the east and south-east

Thick deposits of laterite under very thin soil cover, overlie the Gondwana formation. There is a marginal deposit of laterite which has considerably wide outcrops between the alluvium on the eastern lowlands and the Gondwanas on the western highlands. The thickness of this marginal laterite deposit varies widely. At Gobindprasad it is about 40 feet thick. At Baragarh it is between three and 15 feet thick. Within Bhubaneswar town it is about 16 feet near the Rama Krishna Mission building but 32 feet near the post office, a distance of about one mile. The sandstone exposures on the high grounds were also found to be extensively lateritised at the surface. It is quite possible that laterites underlain by the sandstones occupy an extensive area under the alluvium covered tract on the east and south. Partially weathered pieces of the mother rock is often found associated with it. It is vesicular and water flows very freely through it.

Large stretches of deltaic alluvium cover the lands to the north, east and south of the area. In the highlands only thin strips of light, sandy, river-alluvium are obtained along the course of *nalas*. The depth of this alluvium has not been tested so far, but it is a good aquifer.

It is unlikely that any workable scheme can be made out to create a surface reservoir of safe drinking water for the new capital by damming up any of the *nalas* which flow through the heart of this populated tract.

There are numerous tanks and reservoirs in the Bhubaneswar Union some of which are fed by natural seepages and springs (*e.g.*, the Kedar-Gouri Kunda) and retain a perennial supply of good, clean, fresh water; but many others being very shallow run dry in summer, specially the 'bunds' in the *nala* valleys, or are unclean and polluted. Only very few are kept reasonably clean. Even the Bindusagar which is resorted to by thousands of pilgrims and many local people is far from clean and safe. Some of the existing tanks, important amongst them being the Bindusagar, should be cleaned and re-excavated, and their protective embankments thoroughly repaired. Another existing tank which covers an area of about 22 acres at the eastern margin of the rocky slopes near the betel groves in *Mouza* Baragarh, has been lying in a badly silted up condition. This tank is fed by springs emanating out of the marginal laterite. It could, on reclamation, provide a good source of water supply for local use. Some low earthen dams to impound water may be constructed in the water course and depressions on the western uplands. These will serve two important purposes. Firstly, these can be drawn upon for local irrigation. Secondly, percolation from these will tend to raise the water-table in the neighbourhood and augment the ground water reserves.

In the *nala* basins there is generally a sufficient thickness and saturation of the soil and alluvium. Wells dug in those localities will contain a good depth of water throughout the year. The average daily yield in a 30 to 60 feet deep (depending on location and subsurface geology) and 12 feet diameter well is likely to be over 15,000 to 20,000 gallons at a conservative estimate. In order to improve local supplies the existing wells should be deepened and enlarged. In the deeply laterite covered zones the aim should be to dig at least 10 to 20 feet into the sandstone below.

A few shallow borings, mainly at the bottom of the existing wells, were put down in this area. These water-borings are not deep enough to give a correct appreciation of the pressure gradients of the circulating water in the deeper reaches of the Athgarh sandstone formation. There are no wells in the border zone of the Bhargavi alluvium, which could test the depth of the possible sandstone basement and the hydrological condition of the water therein. It is, however, inferred from the limited available data in the few existing bores that at greater depths the water in the sandstone formation which dips away from the catchment into the perennial valley across the area under consideration should be under artesian head.

It will be useful to put down at least one or two deep experimental boreholes at geographically suitable sites within the area. It may be suggested that a suitable locality would be on the south-east of Baragarh village near the eastern margin of the fallow lands. The boring should be at least 300 to 400 feet deep, and preferably six inches or more in diameter. Another site would be at the road junction off the Puri Bank building. A third site is near mile 2 on the Bhubaneswar-Cuttack Road (east of the Railway Station). As an alternative scheme for the new capital a battery of large diameter (say 15 feet) and deep (at least 100 feet, or 50 to 60 feet into the sandstone basement whichever is nearer) wells at the marginal zone of the alluvium near the base of the rocky slopes is likely to meet the demand of 300,000 gallons of water per day without difficulty. Suitable sites for such groups of wells would be in the Jharpara-Nakhisagar zone, and also near Baragarh.

Mr. S. Krishnaswamy, accompanied by Mr. Kedar Narain, carried out investigations for obtaining large supplies of under-

Balasore, Cuttack and Puri districts, Orissa.

ground water by bore-wells in parts of Balasore, Cuttack and Puri districts, Orissa. Besides Balasore town (21° 30′:86° 56′), the area lying to the west of the Orissa trunk road and north of the Nilgiri road close to the villages Bampada (21° 29′:86° 54′), Udipur (21° 27′:86° 50′), Biruan (21° 27′:86° 51′) and Garpada (21° 27′:86° 51′) was examined in the Balasore district as also the area lying east of the Chandbali road and south of the Basudeopur road, near the villages Bhatatira (21° 03′:86° 34′), Barabhagia (21° 03′:86° 34′), Janasahi (21° 03′:86° 35′) and Serpur (21° 02′:86° 35′). In the Cuttack district the triangular area near Bhadrak bounded by the B. N. R. line on the west and the Jajpur Road on the east lying to the north of the Vyassarobar Dâk Bungalow (20° 56′: 86° 09′) and the Phulnakera area (20° 21′:85° 54′), lying about seven to eight miles south-east of Cuttack town were examined. The above areas are covered by coastal alluvium of varying thicknesses. Bore-hole records from Balasore and Bhadrak show the presence of numerous thick bands of clay intercalated with thin bands of fine and coarse sands. In these localities the water-bearing horizon is likely to be not only deep seated but also incapable of yielding abundant water unlike the areas where the aquifer is more open textured. Fairly good supply of water under sub-artesian condition could be had in some places near Balasore and two promising sites were shown to the Agricultural Engineer, Orissa. At Bhadrak the only promising locality is confined to the bed of a *nala*, just east of the Chandbali road about 2½ furlongs south-west of Serpur village.

Both Jajpur road and Phulnakera areas lie on the thick deltaic alluvium of broad perennial rivers and hence the chances of obtaining large supplies of potable underground water there are generally much brighter than elsewhere.

The upland lying to the north-west of Khurda Road Railway Station (20° 09′:85° 43′) in the Khurda district has been selected for an agricultural farm. The site selected was found to consist of sparsely jointed quartzites dipping N. 10° W. at 75°. As these rocks are not suitable for yielding a large supply, Mr. Krishnaswamy suggested an alternative site farther to the north between the villages Kusumati (20° 11′:85° 44′) and Bhimpur (20° 11′:85° 41′).

Dr. G. Dessau, Geophysicist, accompanied by Mr. Krishnaswamy visited Konarak (19° 50′:86° 08′) Mahakalpara (20° 25′ 30″:86° 35′) and Jambo island (20° 18′:86° 45′) to study the possibilities of applying electrical methods for demarcating the areas of fresh and brackish water. Excepting near Mahakalpara village, the wells in the other areas contain sweet water from the base of low hillocks of blown sand.

Ganjam district, Orissa.

Mr. G. H. S. V. Prasada Rao carried out the investigation of the ground water resources of the area in the Ganjam district lying between the sea and the railway line between Ganjam (19° 23′: 85° 03′) and Chatrapur (19° 22′: 85° 14′) stations on the B. N. R. Water in this area is required both for irrigation and drinking purposes.

The area can be divided into two belts, *viz.*, (*a*) a coastal strip of beach sand and sand dunes, lying east and south of the Humminri *tampara* and (*b*) an area lying west and north of the same *tampara* and consisting of sandy loam, laterite, ferruginous grits and altered gneisses. There are a number of shallow wells in the few villages inhabited by fishermen in the coastal area but they run dry during summer. To supplement the water supply a few more wells along the slopes of the dunes may be sunk. Storage tanks (ten feet × ten feet × ten feet) with cement lining may also be constructed below ground level to collect rain water.

In the western and the northern areas there are ordinary tanks, one of which is fed by water from a branch of the Rishikulya canal. As the tanks have been silted up they should be cleansed so as to afford better storage for the rain as well as the canal water. To prevent the silting of the tanks, foreground cultivation on the catchment area should be prohibited. Wells could be sunk to provide drinking water but the villagers have a preference for tank water. Mr. Prasada Rao considers that water scarcity in this area is due more to inadequate tapping of the existing water supply resources than to any other factor.

Mr. Y. G. K. Murty carried out an investigation of the water supply problem of the area between the villages Ganjam (19° 23′: 85° 03′) and Humma (19° 26′: 85° 05′) in the Ganjam district. The Emergency Irrigation Division, P. W. D., Orissa, proposes to build a low dam across the Rishikulya river near Kanjama (19° 31′: 84° 46′) and construct canals for supplying water to the area north of the river, including the Ganjam-Mumma area. When the scheme materialises the tanks in the area can be replenished by canal water and protected for drinking purposes.

Mr. Murty also recommends that the existing fresh water wells and springs should be cleaned and repaired and a few new wells dug. Storage tanks with cement lining may be constructed for collecting rain water in those villages where the well-water is brackish.

Koraput district, Orissa.

According to Mr. Y. G. K. Murty the Kiajalla spring near Rayagada (19° 10′:83° 25′) can be utilised to supply water to the town as well as the railway colony. Water from the spring issues from alluvium throughout the year and the flow is independent of rainfall. The rate of flow of water varies between seven to eight lakh gallons per day. It appears that the spring is fed by the underground circulation of water from the Nagavali and the Srikena rivers, the beds of both of which are at a much higher level than the site of the spring.

Mr. Murty has also examined the ground water possibilities of Jeypore (18° 51′:82° 34′) and Nowrangpur (19° 14′:82° 33′). According to him a few deep wells may be sunk, away from the rock exposures of the eastern part of Jeypore town (18° 51′: 82° 34′), which is situated on gneisses and charnockites. As the bed rock is likely to be encountered at shallow depths within the town, Mr. Murthy suggests detailed survey of the hill slopes east and south-east of the town for selecting sites for tube-wells.

At Nowrangpur (19° 14′:82° 33′) the ground water table sinks to 40 feet below the ground level in summer. The present wells cannot be deepened further for fear of caving in of the walls of the wells. As most of the wells run dry in summer, Mr. Murty recommends that reinforced cement concrete casings may be used for sinking a few new wells and also for protecting the walls of the existing wells, which may then be deepened further.

RAJPUTANA

Palanpur State, Rajputana.

Mr. G. C. Chaterji paid a brief visit to the Palanpur State, Rajputana, to study the possibilities of lift-irrigation in the western parts. The State forms two distinct physiographic units, the deeply forested Aravalli range of steep and rugged hills on the east and north-east, and the open undulating plains of the west bearing the physical features of a desert country.

Geologically a part of the north-western sector of the State is underlain by the schists and injection gneisses of the Aravalli system. In the eastern hills the schists, phyllites, slates, calciphyre and limestones of the Ajabgarh series occur; but the most prevalent member is the intrusive Erinpura granite. Basic rocks, chiefly dolerite, have also attained a wide spread development.

Alluvial deposits are scarce in the north-east, but increase to the south-west, and merge into the rolling sand dunes of the western plains.

In the hill tracts Mr. Chaterji considers it inadvisable to attempt tube-well borings in the crystalline formation. Sinking of open wells after thorough prospecting for probable zones and deeply soil covered depressions can only be attempted.

An interesting feature of the geology is the existence of the deposits of wind-blown sand covering the valley floors in the foot-hills as described before. This allowed for the various rivers and streams which bear a westerly flow across the State from the hills to the east to traverse over porous and permeable beds even from near their debouchment. It has been noticed that in their upper reaches near the foot-hills these sandy deposits are highly effluent. There are even completely water logged areas, *e.g.*, near the hills about three miles south-west of Hathidera. Further down, about eight to ten miles away from the hills, the river beds become influent.

Thus ground water in the plains of the State is reinforced by (i) the inflow of water from the stream beds into the sand and alluvium, and (ii) by the percolation of rain water into the porous ground. It is very obvious that the aquifers even in the western parts of the State receive a substantial augmentation from the underground flow from the east in addition to the rainfall and the influent water from the neighbouring river beds.

Generally the depth of the water table goes down westwards. This was noticeable from well soundings taken in the summer of 1946:

Hathidera	17½	feet below the surface (average figures).
Lunwa-Sangad	19½	„ „ „ „ „
Palanpur	20	„ „ „ „ „
Ghad-Patosan	30	„ „ „ „ „
Deesa	40	„ „ „ „ „

In Jethabhai Patel's well at Deesa the water-table was at 31 feet. Pumping on this well clearly exhibited that much water is drawn from the Banas river, which flows nearby, by direct percolation. Moreover there is a 150 feet bore in this well from a depth of 52 feet 9 inches.

From a study of the available information and a number of wells distributed over a wide area it was found that though the recovery and drawdown often vary considerably within short distances, the recovery of the cone of depression is quite quick in the whole of the area so far known. Mr. Chaterji is of the opinion that in the plains of Palanpur larger and deeper (60 feet and more) dug wells may be expected to cope with demands of 10,000 gallons per hour or so. The experience gained in the United Provinces suggests that much further increase in the output is likely to be achieved by putting down 150 to 300 feet deep boreholes below the bottom of the wells unless solid rock is touched at a much shallower depth. Deep experimental tube-wells, 300 to 400 feet in depth were recommended at selected areas.

UNITED PROVINCES

Dehra Dun district, United Provinces.

Dr. M. R. Sahni investigated the site of a well at Nalapani to supply water for irrigation purposes to the surrounding area. Nalapani (30° 20′:78° 5′ 30″) is situated at grid 588:875 in sheet 53 J/3, about four miles from Dehra Dun, near the foot of the Kalanga Hill.

Kalanga Hill is composed of Mandhali slates and quartzites overlain by high level Dun gravels, the Mandhalis being separated from the Siwaliks by the boundary fault which runs near the western foot of the hill. Nalapani is already well known for its spring, the water of which is noted for its softness, having, according to Dr. Auden, a hardness of only six to eight parts in 100,000. The main Nalapani spring, as also some of the subsidiary springs appear to follow the Mandhali-Dun gravels junction, issuing at the surface at various points. On the land where the well is required, the high level Dun gravels cap the Mandhalis which are found at a depth of about 35 feet below ground level. Sub-soil water in this area would, therefore, be expected to occur at or near the junction of the gravels with the Mandhalis, *i.e.*, at a depth of about 30 feet. It must however be stated that the thickness of these gravels does not appear to be constant by any means, and variations are likely to occur. The land in question constitutes a terrace (presumably not a natural one) above the river bed, and is situated considerably below the crest of the main ridge, so that a fair thickness of high level gravels occurs here. These would assist in the storage of rain water which, as already mentioned, issues forth as springs in the neighbourhood. An examination of the land in question shows that minor seapages occur on it. One of these is seen just above the depression near the farm house. Therefore, if water is likely to be found on this land, this locality appears to be more suitable than any other within the area. Dr. Auden, who is familiar with this area has pointed out that there can be no certainty of obtaining large quantities of water here. However, in view of the favourable situation and the fact that there is no other more suitable alternative site, Dr. Sahni considers it worthwhile taking the risk of sinking a well here.

OTHER ALLIED ENQUIRIES

BOMBAY

Soil researches, Bombay.

Mr. P. K. Chatterjee visited the Soil Research Institute at Sholapur and other agricultural research stations in the Bombay Presidency and made a study of the measures adopted for preventing the erosion of soil.

At Sholapur, Mr. Chatterjee studied the different methods of checking soil erosion, *viz.*, (i) Contour bundings, (ii) Contour strip cropping, (iii) Rotation of leguminous crops, etc., as adopted by the Bombay Dry Farming methods. He also studied the land improvement work in the Bijapur and Dharwar districts, where soil erosion is checked by contour trenching and aforestation methods in addition to contour bunding, terracing and cultivating the terraces. In the Dharwar district the methods of reclaiming alkaline soil were studied by him and at Tembhurni, Sholapur district, the methods employed to study the soil-erodibility, fertility and permeability of the soil were examined. Mr. Chatterjee also studied the methods of soil survey and soil-classification at Padegaon Farm in the Satara district.

CENTRAL PROVINCES

Township sites, Betul and Saugor districts, Central Provinces.

In connection with the Government of India proposal to create a township for 200,000 people, the areas around Betul (55 G/13; 21° 55′:77° 54′) and Saugor (55 I/9 and 13; 23° 50′:78° 45′) in the Central Provinces and Berar were examined by Mr. G. C. Chaterji in May-June 1948 with a view to reporting on the climate, conditions for building and water supply. The requirement of water was indicated at six million gallons per day. Mr. Chaterji has also considered the aspects of communications by road, rail and air of Betul and Saugor with the various important towns and ports in India. Betul is centrally situated. At present the railway connections for Betul, on a mail-train-running route, are more convenient than that for Saugor, on a branch line. The provincial airport of Nagpur is nearer Betul than Saugor.

Betul (2,100 ft.) is 400 feet higher than Saugor (1,700 ft.), and enjoys cooler temperatures in summer. Rainfall at Saugor (57 inches) is slightly above that at Betul (54 inches). The climate of Betul appears to be more bracing than that of Saugor. As regards health Betul can improve on Saugor if proper arrangements are made.

On the southern Satpura hills the country around Betul (Badnur) is situated in an enclosed plateau surrounded by uneven hilly country. An area of fifty square miles around Badnur (55 G/13; 21° 55′:77° 54′) (Betul district H.Q.) including the gorge of the Tapti river between the Illichpur road bridge and Layawani (21° 46′:77° 49′) as well as the basin of the Sampna *nala* off Jhitapati (55 K/1; 21° 52′:78° 02′) was rapidly gone over.

Southwards of Badnur, there is a wide expanse of fairly flat ground covering many square miles, till the Tapti river is reached about ten miles away. This river runs through a narrow, rocky gorge with an average depth of about 400 feet below the level of the plateau. In summer the river dwindles to a very meagre stream; but in the monsoon it is known to swell enormously. The other two streams nearer to Badnur-Betul are the Sampna and Machna tributaries, but they meander through comparatively shallow defiles on the flat top of the Betul plateau.

The rock succession exposed in the area is:—

4. Deccan trap—covering the area south of Kheri-Arul axis.
3. Lametas—small patches west of Degaon.
2. Gondwanas—in the valley of the Tapti near the Ellichpur Road.
1. Crystalline-gneisses—north of the Kheri-Arul axis.

The exposures of the Gondwanas and the Lameta sedimentaries are of no material significance.

The Crystalline gneisses and the Deccan trap basaltic lavas and dolerites constitute the prevailing formations underlying the

Betul plateau. There are frequent outcrops of these rocks, and the soil cap is generally inconsiderable.

The area examined around Saugor was covered by traverses between the Dhasan-Karawar river junction (23° 58′:78° 40′) on the north, the Bewas river near Berkheri (23° 45′:78° 49′) and Piparia Ramban (23° 45′:78° 51′) on the south, the Dhasan River near Mohana (23° 48′:78° 33′) on the west and Makronia (23° 51′: 78° 48′) on the east. Saugor is an ancient town. It has grown around an artificial lake which now exists in a badly polluted state. It has silted up considerably It is not considered to be of much use to the population except as a feature adding scenic beauty to the town looked at from a respectable distance.

The average altitude of the country around is 1,700 feet above M. S. L. It is a rolling plain dissected by innumerable water courses and studded with irregular hills, mounds and steep ridges. This makes the surface generally uneven with occasional narrow strips of flat ground. The general slope of the ground is towards north and east. The areas to the north and south of the town are hilly.

There is no river with any appreciable dry weather flow near about; and none of the neighbouring rivers has a proper valley defile, within a radius of 20 miles from Saugor, for the creation of a collected reservoir of sufficient capacity by damming up of the monsoon run off.

Hard and compact rocks generally underlie both the areas but a thicker mantle of loose and incoherent soil in the country around Saugor would require deeper and more costly foundation works. Moreover a wide extent of practically level and little disturbed surface southwards of Betul would allow more scope for symmetrical planning of a new township as well as for its future expansion than in the extensively dissected parts around Saugor.

Groundwater conditions are not encouraging in the hard and impervious rocks in either area. Subject to confirmation by detailed geological examination there is a good dam-site in the narrow gorge of the Tapti river near Layawani (556/13; 21° 46′: 77° 49′) (55 G/13; 21° 46′:77° 49′) about ten miles south-west of Betul (Badnur). If considered solely for town water supply, a low dam (say 100 to 200 feet high) may store an adequate reserve; but connected with the scheme for the multipurpose development of the Tapti valley there is scope for a 300 to 400 feet high dam founded on solid Deccan trap. There is no site for a dam which can create a reservoir of adequate capacity within a radius of 20 miles from Saugor.

SAURASHTRA

Brine recovery, Rann, Saurashtra.

In response to a request from the Salt Controller, Government of India, New Delhi, a joint tour of the Kharaghoda salt works was carried out by Dr. B. C. Roy towards the end of February, along with the Director of Irrigation, C. W. I. N. C., with a view to examining the following alternatives for obtaining the brine, in preference to the present well and bucket arrangements:—

1. Working mobile pumps for drawing brine from groups of wells.
2. Sinking tube-wells.
3. Laying subterranean perforated pipe lines connected to a central pumping station.
4. Constructing percolation canals converging to a central pumping station.

The salt works comprise a N.W.-S.E. strip of the Rann (about ten miles long and five miles wide), covered during the monsoon by a thin sheet of water which is partly sea water, forced into it by the strong winds from south-west and S.S.W. and partly flood waters of the rivers from adjacent territories. When the tract becomes dry in summer, brine, which occurs in lenticular sand patches at different levels within 15-40 feet from the surface, is tapped by sinking several hundreds of new wells or opening the older ones.

The proposal for drawing brine from groups of wells by working mobile pumps is not recommended. The poor capacities of the wells, yielding 0·01 to 0·02 cusecs, is not favourable for uniform working with the aid of mechanically driven pumps. The use of hand operated pumps will be efficient and economical.

With a view to tapping all brine horizons at a shallow depth, excavation up to a depth of 40 feet would be necessary for the construction of the proposed canals. The cost of construction and maintenance of a system of canals will be highly prohibitive. Besides, the underground currents of brine would be too feeble to feed the canals, and there is the possibility of the brine being weakened by sweet ground water.

The laying out of subterranean perforated pipes will not be a feasible or economical proposition in view of the marked irregularities of the brine horizons. Excavation up to a depth of some 40 feet and provision for pipe lines over long distances would be needed. Dilution of good brine with weak brine or sweet water currents is inevitable.

The most efficient and economical proposition for improving the methods would eventually be the sinking of hand operated tube-wells, with provision for some mechanisation in case of those with fairly copious yield, and the construction of permanent wells throughout the salt works. Sinking of one dozen tube-wells and one dozen permanent wells is recommended as test measures.

The areas showing brine of weak, medium and high densities have been approximately delineated on a plan by Dr. Roy, and it is suggested that the future working should be normally restricted to areas yielding good brine.

VI. HEADQUARTER'S TECHNICAL SECTIONS

CHEMICAL SECTION

During the period under review, the strength of the Laboratory consisted of one Chemist, nine Assistant Chemists and four Laboratory Assistants. The two posts of Assistant Chemist that fell vacant last year due to the two incumbents opting for Pakistan were filled in the middle of this year.

The number of samples tested and analysed this year was 1,359 against 1,012 in 1947 and 544 in 1946. They are roughly classified as follows:—

(1) 665 samples of non-metallic minerals such as limestone, gypsum, bauxite, magnesite, sillimanite, clays, felspars, fluorspar and sands were analysed for finding out their suitability for use in cement, fertilizer, ceramic, refractory and glass industries.

(2) 118 samples from Lowa Gold mine were assayed for precious metals. Further laboratory investigations were undertaken with a view to finding out how best the extraction of gold could be effected on an economic basis.

(3) 141 samples of metallic minerals were examined and analysed. These include mostly copper, iron, manganese and gold and silver bearing minerals. The exploration work for copper in Rajputana and the prospecting work for the same metal in Darjeeling district required a lot of copper-ores to be analysed for copper and associated metals. The prospecting for sulphur in Bihar necessitated the analysis of a large number of samples of pyrites. Iron-ores were analysed for the proposed steel plants.

(4) 362 samples of coal were analysed for finding out their suitability for use as raw material in the manufacture of synthetic petroleum.

(5) 3 samples of rare and radio-active minerals were analysed during this period. They were beryl and uranosphærite.

(6) 70 samples of miscellaneous nature were analysed for different purposes.

Two field laboratories were established under two Assistant Chemists—one in the Sirmur State and another in Bihar for the expeditious analyses of gypsum and coal respectively.

PETROLOGICAL SECTION

Staff.

Dr. A. G. Jhingran continued to act as Petrologist up to the 27th November, 1948, when he was relieved by Mr. A. B. Dutt who acted in that post up to the end of the year. Mr. P. K. Ghosh continued as Curator till the 27th April, when he left for camp. Mr. D. Gupta took charge as Curator for sometime on his return from camp. Mr. S. N. Sen relieved him in early August, 1948 and continued till the end of the year. Mr. N. A. Vemban worked as Assistant Petrologist throughout the year except during the period from 7th June to 22nd July 1948, when he was on leave and Mr. K. Balu worked in his place. Mr. G. L. Wakhaloo, Geological Assistant, was attached to the Section throughout the year; and during the year he was joined by Messrs. S. K. Das Gupta and Ch. Narasimha Rao, Technical Assistants and Mr. B. N. Jayaram, Geological Assistant. Messrs. A. Mitra and A. K. Saha, Geological Assistant and Mr. C. Suri Sastry, Technical Assistant, also worked in this section. The first two were later transferred to the Engineering Geology Section; Mr. Suri Sastry left the Department on the 14th December 1948.

Determinative work.

Determinative work was carried out in the Petrological Laboratory on 1452 specimens. Besides geological information was supplied to various industrial concerns and parties interested in minerals and rocks.

Donations.

Presentations of rocks and minerals were made to the following institutions or parties during the year:

1. Loreto House, Calcutta.
2. Bengal Engineering College, Sibpur, Howrah.
3. Agricultural Chemist, Government of Bombay.
4. Massachusetts Institute of Technology, U.S.A.
5. Dr. K. L. Rao, Ramapadasagar Project, Madras.
6. Indian Institute of Science, Bangalore.
7. Geography Department, L. D. Arts College & M. G. Science Institute, Ahmedabad.
8. B. M. Sreenivasiah College of Engineering, Bangalore.
9. Geology Department, Presidency College, Calcutta.
10. Grammar School, Canberra, Australia.
11. Annamalai University, Madras Presidency.
12. Council of Scientific & Industrial Research, Melbourne, Australia.

13. Burma Corporation. Burma.
14. Chemistry Department, University College of Science & Technology. Calcutta.
15. College of Agriculture. Dharwar, Bombay.
16. Birla Vishvakarma Mahavidyalaya, Anand, Bombay.
17. Director, National Physical Laboratory, Delhi.
18. College of Engineering & Technology, Jadavpur, Bengal.
19. Chief Commissioner, Himachal Pradesh, Simla.
20. Physics Department, Indian Institute of Science, Bangalore.
21. Mr. K. K. Majumdar, Indian Institute of Science, Bangalore.
22. Government High School, Damoh.
23. Shri Shivaji Maratha High School, Amraoti.
24. Department of Geology, Banaras Hindu University, Banaras.
25. Birla Vishvakarma Mahavidyalaya, Vallav Vidyanagar.
26. St. Xavier's College, Ranchi.
27. A. C. College of Technology, Saidapet, Madras.
28. Gaya College, Gaya, Bihar.
29. Siddharth College, Bombay.
30. Government College, Coimbatore, Madras.
31. Government College, Rupar, East Punjab.
32 Karnatak College, Dharwar, Bombay.
33. Vigyan Kala Bhaban, Meerut, U. P.
34. Divisional Forest Officer, Ajmer-Merwara.

Museum Work.

267 specimens were added to the mineral and rock collections and 313 specimens to the duplicate collection in the Mineral and Rock Galleries of the Indian Museum during the period under review. Estimates of costs were made for preparing plaster casts of meteorites that fell in the area now included in Pakistan. A plan has also been drawn up and steps are being taken to start an Industrial Mineral Section in the Mineral Galleries of the

Indian Museum and some progress has been made in that direction. In addition to the usual collections of minerals and rocks made by officers during the year, the following material consisting of 153 specimens was presented to the Department:—

1. Royite from Mr. N. L. Sarma, Indian School of Mines, Dhanbad.
2. A set of iron-ores, ferro-alloy minerals and metallurgical coke, etc., from Messrs. Tata Iron & Steel Co., Jamshedpur.
3. A collection of minerals of Italy and Switzerland from Dr. G. Dessau.
4. Galena from Messrs. Jayanta Lead Mining Corporation.
5. Beryl ore from Collector and Deputy Commissioner, Ajmer.
6. Chalcopyrite from Mr. P. C. Dutta, Jubbulpore.
7. Antimony-ores from the Star Metal Refinery, Bombay.
8. Gypsum from Messrs. British Metal Corporation (India) Ltd., 22, Chittaranjan Avenue, Calcutta.
9. Copper-ore from Nanubhai Hariprasad Bhatt, Bombay.
10. Specimens of copper-ores, concentrated matte, slag, etc., from Indian Copper Corporation Ltd., Ghatsila.
11. A set of aluminium-ores and accessories from Messrs Aluminium Corporation of India Ltd.
12. Steatite from Messrs. Hirji Premji Parmar & Bros.

Micro-sections.

The Petrological Section prepared 1,475 micro-sections of rocks and minerals during the period under review.

Meteorites.

During the year a stone meteorite which fell at Sarratola village, Sidhi tahsil, Rewa State, Vindhya Pradesh, Central India, was presented by the Mining Adviser, Vindhya Pradesh. It is under examination in the Department.

PALAEONTOLOGICAL SECTION

Staff.

Mr. P. N. Mukherjee continued as Palaeontologist throughout the year. Mr. M. V. A. Sastry, Assistant Palaeontologist, also continued throughout and assisted the Palaentologist in general routine work. Mr. K. N. Prasad, Geological Assistant, assisted the Palaeontologist in the general rehabilitation and re-organisation of the

Siwalik gallery. Mr. B. D. Tewari, Geological Assistant, assisted in the general rehabilitation of the Invertebrate fossil gallery, and in putting up representative sets of fossil specimens for presentation to scientific and educational institutions. In November 1948, Mr. Tewari was transferred to the Engineering Geology Section for field-work. Mr. B. K. Baweja, Geological Assistant, assisted the Palaeontologist in the general rehabilitation for a short period, and was later transferred to the Engineering Geology Section and left for field duties about the middle of February 1948. Messrs. B. R. Cheluva Iyengar and V. Raghavendra Rao, Geological Assistants, joined the Palaeontological Section about the middle of July 1948, and assisted the Palaeontologist in the general rehabilitation work of the Invertebrate
tologist in the general rehabilitation work of the Invertebrate
on transferred from the Palaeontological Section in the middle of November 1948 and left for field duties in the Simla hills.

Siwalik Gallery

Rehabilitation and re-organisation work in the Siwalik Gallery.

Considerable progress was made during the year, regarding the rehabilitation work in the fossil galleries of the Indian Museum. A large number of photographs of some of the extinct mammals of India, as well as popular descriptive labels in two to three languages were introduced in the Siwalik gallery. With the addition of charts showing the evolution of man and the apes, as well as of the horse and the elephant, the gallery has become more attractive, interesting and instructive.

The re-organisation work of the Siwalik gallery was carried out extensively, much attention having been devoted to restoration of fossils and casts damaged during the period when the galleries were under military occupation. One of the most interesting show cases of the gallery, namely, that of the fossil anthropoid apes, was renovated and the exhibits were re-arranged with photographic illustration and charts. His Excellency Lord Mountbatten of Burma paid a visit to the Siwalik gallery in the first week of March and envinced keen interest in some of the fossil exhibits.

One of the finest collections of the Indian fossil Bovidae, constituting 12 cases of material, described and figured by the late Dr. Pilgrim (*Pal. Indica,* Vol. XXVI, 1939), was lying with the Keeper of the British Museum during the war period. These were received back about the middle of 1948. The specimens were unpacked, classified and some of the best types were exhibited in the gallery in two show cases by Mr. N. K. N. Iyengar assisted by Mr. K. N. Prasad.

Invertebrate Fossil Gallery

Forty show-cases, containing fossil specimens ranging in age from the Jurassic to Sub-Recent and Recent, housed in the eastern portion of the gallery which was closed to the public for a long time, have been reinstated. New printed labels are now being inserted. The entire gallery has been thrown open to the public since the middle of December, 1948.

The collection of Neocomian cephalopods from the Salt Range, examined and returned by Dr. Spath, was finally checked by Mr. Sastry. The collection comprises a large number of duplicates and some types, which have been registered and stored. Mr. Sastry was engaged in unpacking, checking and storing 40 cases of type fossil specimens, out of 47 cases of such material received back from Dehra Dun.

Some of the old exhibits of fossil ammonites in the Kachh Jurassic show-cases are now being replaced by better specimens selected from a large collection of Kachh Jurassic cephalopods, revised by Dr. Spath, which were lately received back in the Department.

About 40 specimens were restored in the fossil galleries of the Indian Museum, some of the most important fossils and casts restored being:—

(1) *Colossochelys atlas* Falc. and Caut.
(2) *Crocodilus palaeindicus* Falc.
(3) *Icthyosaurus longirostris* Falc.
(4) *Dissopsalis carnifex* Pilg.
(5) *Giraffokeryx.*
(6) *Sivapithecus.*

Vertebrates

A specimen of a fossil bone, collected near Kalhanpur, near Bihata in Bihar, was sent by the Curator, Patna Museum, for examination. The specimen was provisionally identified by the Palaeontologist as a metacarpal of *Bos namadicus* Falc., recorded to occur in abundance in the Siwaliks of the Narbada Valley. The measurements of the metacarpal indicate that the specimen is closely related to the European specie *Bos primigenius*. The occurrence of *Bos namadicus* in Bihar is of great interest as this find may lead to the discovery of many closely related fossil specimens in the neighbourhood.

Two more fossil tortoise shells from the Worli Hill, Bombay, collected by Dr. Sukheswala of the St. Xavier's College, Bombay, were received for identification. The specimens were poor, one representing a portion of the shell, and the other a portion of the carapace, showing fragments of plates. These were identified by the Palaeontologist as *Hydraspis leithii* Gray, the age of the fossils being Intertrappeans (Upper Cretaceous to Lower Eocene).

Four specimens of the so-called carbonaceous shales with fossil impressions were sent to this Department by the Mining Adviser to the Government of Central Provinces and Berar for identification. The specimens were collected from near Raibasa, in the Chhindwara district (Sheet 55 K/10); the country was geologically surveyed originally by Dr. H. Crookshank as Deccan trap. The fossils were presumably collected from some Intertrappean band, though no such band is shown in the geological map. It is interesting to note that the Palaeontologist identified a small fossil tortoise shell closely related to the young individual of the genus *Hydraspis* probably identical with *Hydraspis leithii* Gray. The three other specimens are imperfect plant remains which could not be specifically identified. Microscopic examination of the rock associated with the fossil shows volcanic tuff with amygdaloidal basalt—presumably suggesting an association of the Intertrappeans with the Deccan trap, approximating in age from the uppermost Cretaceous to Lower Eocene.

Invertebrates

A collection of fossiliferous shales and clays (*Fuller's earth* or *Multani mitti*) made by Dr. Crookshank from near Madh in Bikaner State, Rajputana, was sent to the Palaeontologist for examination and report. The following identifications were made:—

1. *Venericardia mutabilis* (d'Arch. and Haime).
2. „ cf. *subcomplanata* (d'Arch. and Haime).
3. „ cf. *sindiensis* (d'Arch. and Haime).
4. *Volutilithes* sp. cf. *cithara* (Lamk.).
5. (?) *Corbula* (*Bicorbula*) *subexarata* d'Arch.
6. *Pecten* sp.
7. (?) *Nuculana* sp.
8. (?) *Glycimeris* sp.

9. *Ostrea* (*Liostrea*) sp.
10. *Dentalium* sp.
11. (?) *Ditremaster* sp.

The general faunal assemblage indicates an age approximating to Middle Eocene.

It is interesting to note that the late E. Vredenburg discovered a few formanifera and an oyster from the Palana coal-bearing beds in Bikaner State, namely, *Nummulites atacicus*, *Assilina granulosa* and *Ostrea multicostata*—the faunal assemblage indicating a Middle Eocene age (*Rec. G. S. I.*, Vol. 36, Pt. 4, p. 314).

A collection of nearly 20 fossil specimens was brought by Swami Pranavananda to the Palaeontologist for examination. The specimens identified were chiefly Cephalopoda, having Jurassic affinities. A detailed account of the report was sent to Swami Pranavananda.

A collection of fossils from Meyong Disa, Mikir Hills, Assam made by Mr. D. K. Chandra, was referred to the Palaeontologist for examination. Macroscopic examination of the specimens revealed *Nummulites* sp., *Assilina* sp., *Venericardia mutabilis* and *Ostrea.* Microscopic examination of slides showed *Assilina spira* and *Nummulites obtusus,* characteristic of the Kirthar stage of the Eocene.

A small collection of fossils, mostly casts of Mollusca and Ostracoda from near Ellichpur, C.P., made by Mr. S. M. Mathur was examined by the Palaeontologist. *Vivipara* sp., *Melania* sp., *Pupa* sp. and *Cypris* sp. were recognised.

The fossils occur in thin cherty and calcareous bands, associated with the Deccan trap. The beds in which the fossils occur are Intertrappean.

A collection of fossils, mostly mollusca, from Nawanagar State, Kathiawar, Bombay Presidency, made by Mr. D. R. S. Mehta is being examined by Mr. P. N. Mukerjee and Mr. M. V. A. Sastry. The following have been noticed:—*Clementia papyracea* (Grey), *Ostrea latimarginata* Vred., *Montlivaltia jacquemonti* d'Arch. and Haime, *Dosinia* sp., *Cardium* (*Trachycardium*) sp., *Omphaloclathrum* sp., etc. The general faunal assemblage indicates that the geological horizon of the fossiliferous beds is Miocene (Burdigalian).

A miscellaneous collection of fossils from different localities was sent to the Palaeontologist by Professor H. D. Sankalia of the Deccan College, Poona, for examination. The fossil specimens identified in the collection mostly belong to the genus *Ostrea* (*Alectryonia*) with species *carinata* and *diluviana,* and *Exogyra ostracina,* which are characteristic of the Cretaceous. Besides, a specimen of *Perisphinctes* and a *Belemnite* were noticed, indicating a doubtful Jurassic or Cretaceous age.

A collection of fossiliferous limestones from near Godavari (27° 36′:85° 23′) about 9 miles south-south-east of Khatmandu, Nepal, sent by Dr. J. B. Auden and Mr. A. K. Saha on examination reveals indistinct and imperfect sections of Crinoid stem fragments showing circular and elliptical sections. The Crinoidal fossil remains are poor in view of the extremely delicate constitution of the skeletal parts and the looseness with which the segments are united. In addition to the fossil Crinoidal remains, there are a few imperfect shells resembling those of the Brachiopoda—the shells have been completely mineralised and therefore nothing can be distinctly seen in them. The general faunal assemblage is suggestive of a Palaeozoic age for the beds, though there is every possibility of these beds ranging up to Triassic. Crinoidal fossil remains occur moderately in the Palaeozoic of India and Burma, though such fossil remains form beds of considerable thickness in Europe, ranging in age from the Palaeozoic to Mesozoic.

A number of core samples from a locality near Gunga in Jodhpur State were sent by the Jodhpur Darbar to the Department for microforaminiferal and other examinations with a view to finding out the age of the individual cores encountered, and to ascertain the possibility of striking coal at some depth. Some greenish pyritic shales met with in the Gunga well at a depth of 180 feet from the surface were provisionally correlated with the coal-bearing beds (Patala Beds) at Dandot, Salt Range. Since coal was expected at a depth of about 280 feet from the surface, a borehole was put down to about 300 feet; however, no coal was found.

The results of the microforaminiferal examination of the borehole cores by the Burmah Oil Co. (India concessions), in their laboratory at Calcutta, show that the most of the specimens are barren excepting some samples collected at depths of 290 feet, which show some *Ammobaculites;* these however, are not diagnostic for age determination.

The tentative correlation of the pyritic shales in Gunga well in Jodhpur with the highly fossiliferous and coal-bearing Patala Shales in Salt Range, based presumably on lithological grounds and inadequate palaeontological evidence, led to the failure of locating coal-bearing horizons.

Donations

During the year presentations of small collections of fossils were made to the following persons or institutions:—

1. Dr. Joshua, Professor of Zoology, Madras Christian College, Tambaram, Madras.
2. Mr. S. C. Kaul, Central High School, Srinagar, Kashmir.
3. Mr. Sripada Rao Kilpaudy, Head of the Department of Geology, Nagpur University, Nagpur.
4. The Professor of Geography, L. D. Arts College & M. G. Science Institute, Ahmedabad.
5. The Principal, Karnatak College, Dharwar.
6. The Chief Commissioner, Himachal Pradesh.
7. The Principal, Gaya College, Gaya.
8. Head of the Department of Geology & Geography, Siddartha College, Fort, Bombay.
9. Dr. Mahadevan, Professor of Geology. Andhra University, Waltair.

Department of Anatomy, Edinburgh University, was supplied with ten casts of Siwalik Fossil Primates on payment of the cost of preparation and despatch.

Additions to the Collections.

During the year the Department has received fossil specimens from the following:—

Presentation.—Burmah Oil Company (India Concessions) Ltd., Calcutta—A set of fossils indicative of oil beds.

Dr. Sukheswala, St. Xavier's College, Bombay—Two specimens of *Hydraspis leithii* Gray, from the Intertrappeans of Worli Hill, Bombay.

Exchange of fossil specimens.—Two plaster casts of mandible and a facial fragment of *Proconsul africanus* Hopwood, from the Miocene of Kenya, were received from the Curator, Coryndon Museum, Kenya, in exchange of some plaster casts of anthropoid apes from the Indian Siwaliks.

Purchase.—320 microforaminiferal slides constituting topotype material were purchased from Dr. Cushman, U.S.A.

In response to a request from the Honorary Secretary, Board of Trustees, the Indian Museum, a short note with photographic illustrations of some of the important palaeontological exhibits was prepared for incorporation in the Museum Guide under preparation.

At the request of the Museum Association of India, a short account was prepared on the palaeontological collections in the Indian Museum and forwarded to the authorities.

PALAEOBOTANICAL SECTION

Dr. K. Jacob was in charge of the Section of Palaeobotany during the year. Mr. K. N. Prasad assisted the Palaeobotanist in routine and research work.

Dr. (Mrs.) Chinna Jacob, Ph.D., was granted permission to carry out research work in the palaeobotanical laboratory.

Investigations

Besides continuing the detailed examination of several earlier important collections, the following investigations of specimens received during the current year, were in progress:—

Darjeeling gneiss.—Specimens of "carbon phyllite" occurring within the Darjeeling gneiss, were handed over for investigation, as Mr. K. K. Dutta, who collected the specimens, has doubts regarding the age of the Darjeeling gneiss as generally accepted, and suspects a possible sedimentary origin for the same. On maceration, the specimens yielded no organic remains. Further samples are awaited.

Vindhyan.—Undoubted organic remains were discovered in certain ferruginous sandstones reported to be the Upper Bhanders. The specimens were collected by Mr. G. V. Rao from the top of a hill near Gugri, Maihar State, Central India.

Dr. Jacob who examined the collection reports that it includes fairly large pieces of fossil wood which, in thin sections, hardly reveals any clear structure owing to the deep reddish brown pigmentation of iron oxide. But in preparations of the woody elements teased out in clove oil, bordered pits are clearly visible. A few triangular trilete spores showing the triradiate mark were also found in some of the preparations.

This discovery would be of outstanding interest if the specimens are undoubtedly referable to the Upper Bhander sandstone. In the first place, authentic records of past life in the Vindhyans are rare. Secondly, such highly developed wood as those now under investigation, are not known from strata earlier than the Devonian. The earliest known land plants occur in the Upper Silurian of Victoria, Australia, but the woody tissue of those plants shows primitive organisation without any secondary growth. If the Maihar specimens are from undoubted Bhander sandstone, it would appear that the Vindhyan sedimentation probably extended up to the Devonian and was not entirely limited to the Precambrian according to some investigators, or to the Cambrian as suggested by others. The other possibility is that the specimens occur in hitherto unnoticed younger strata overlying the Vindhyan system. The examination of the available specimens is being pursued. The heavy mineral assemblage of the fossiliferous sandstone is also being determined.

Lower Gondwana.—(1) Specimens of tillite (? Permo-Carboniferous) from the Abor hills were examined for possible organic remains without success. (Collection: Dr. A. K. Dey.)

(2) Representative samples of coal from some of the seams of the West and East Bokaro Coalfields were received for microspore analysis and correlation of the seams based on spore data. (Collection: Mr. A. B. Dutt.)

(3) Two collections of Lower Gondwana plant fossils from the Chanda district, Central Provinces, were examined. Those from Isapur (Kamthi) comprise several specimens of *Glossopteris indica* and *Phyllotheca indica.* Those from Devai Govindpur belong exclusively to *Gangamopteris cyclopteroides and Gangamopteris* sp. and should be referred to a lower horizon, probably the Barakars. (Collection: Mr. S. M. Mathur.)

(4) A sample of metamorphosed coal believed to be from the Lower Gondwanas of the Kosi dam site area, showing certain striations simulating woody structure, was examined for any undoubted organic remains that may be present. Maceration yielded negative result, all traces of organic matter, if originally present, having been destroyed during metamorphism. (Collection: Dr. J. B. Auden.)

(5) Specimens of shale collected from the Permo-Carboniferous of the Pench Valley area yielded numerous gymnosperm spores most of which have already been described in previous years from the Permo-Carboniferous sediments occurring elsewhere. From this area, however, very few fossils have been reported previously. (Collection: Dr. H. Crookshank.)

(6) Systematic examination of the micro-fossil content of the Gondwana coals and carbonaceous shales initiated last year was

continued. Owing to want of adequate technical assistance progress of work has been slow.

(7) Specimens of Lower Gondwana plant fossils from Nayagarh and Kharkari were identified as *Glossopteris indica* and *Vertebraria indica.* (Collection: Mr. K. Balu.)

Upper Gondwana.—(1) Two specimens of poorly preserved fern fronds from the Gondwana beds near Ellichpur, Amraoti district, were examined at the request of Mr. C. N. Chary, Office of the Geological and Mining Adviser, Government of Central Provinces and Berar, Nagpur. It was reported by him that no fossils had been hitherto found in these beds near Ellichpur and consequently there was some doubt regarding their stratigraphic position. The specimens examined were identified as *Cladophlebis denticulata,* a common Mesozoic fern frond. In the opinion of Dr. Jacob these beds should be referred to the Upper Gondwanas. (Collection: Mr. C. N. Chary, Office of the Geological and Mining Adviser, Government of Central Provinces and Berar, Nagpur, C.P.)

(2) A piece of petrified gymnospermous wood from the "Jaisalmer border" has been identified as *Mesembrioxylon* sp., a genus fairly common in the Jurassic and extending up to later times. (Collection: Dr. H. Crookshank.)

Intertrappean (Deccan).—Specimens of Intertrappean carbonaceous shales from Raibasa, near Ambara, Chhindwara district, sent by the Geological and Mining Adviser, Government of Central Provinces and Berar, yielded well preserved microspores on maceration. Similar Intertrappean shales from Worli Hill and also from a locality near Indore examined recently in the laboratory, yielded very similar spores and other plant microfossils. The investigation when completed would give us valuable data on the age of the Intertrappean and its microfloras about which our knowledge at present is very meagre.

Tertiary.—(1) Collections of leaf impressions and seeds from the Cherra stage of the Garo hills were under investigation. In Dr. Jacob's opinion the plant remains may more properly be referred to the Tertiary (Eocene) than Cretaceous. All the plant remains are angiospermous and one palmately compound leaf may possibly belong to the Euphorbiaceae. Some of the specimens are in the form of "compressions" and maceration has yielded fairly satisfactory cuticular preparations which would be helpful for closer identification with some of the modern flowering plants. (Collection: Mr. B. Laskar.)

(2) Leaf impressions from the Daling Kot Colliery area were found to be remains of dicotyledonous plants. According to Mr. Poddar, they were collected about half a mile south of the colliery. The dicotyledonous leaf impressions cannot be older than Cretaceous but are probably Tertiary in age. The samples of coal from his collection yielded only a single type of non-angiospermous microspore with few tracheids and seeds of gymnospermous affinity. It is very likely that the coal and the leaf impressions are from two different horizons, the former probably belonging to the Lower Gondwana. (Collection: Mr. M. C. Poddar.)

(3) A few plant impressions collected from certain shale beds in the gorge of the Lohendra nala, near Shikarbar (Morang district, Nepal), were suspected to belong to the Damudas. But the presence of an undoubted dicotyledonous leaf indicates that they are probably Tertiary in age and certainly not older than the Cretaceous. Some parallel veined leaves contained in the collection may belong to the Monocotyledonae which also became abundant in the Tertiary and later times. This collection is of some interest and attempts to get satisfactory preparations of cuticles are being made. The shales have undergone slight metamorphism. So far no microspores have been obtained. (Collection: Mr. A. S. Ramiengar.)

(4) A piece of petrified wood from the Boka Bil stage (Upper Surma), Tripura State, has been identified as a Tertiary dicotyledon possibly belonging to the Leguminosae. The details of internal structure are not sufficiently well preserved for a closer identification. (Collection: Dr. A. K. Dey and Mr. V. H. Boileau.)

(5) A few specimens of poorly preserved plant impressions from the "*Multani mitti*", Kapurdi, Jodhpur, were examined. There was only one satisfactory specimen of a dicotyledonous leaf impression which has been referred provisionally to Seward's form genus *Phyllites*. (Collection: Dr. H. Crookshank.)

(6) Pieces of petrified wood from Suri, Birbhum, are under investigation. The dicotyledonous wood most probably belongs to the Tertiary. A close decision is at present not possible owing to the poor preservation of their internal anatomy. (Collection: Mr. M. P. Guha, Department of Agriculture, West Bengal.)

(7) Specimens of sandstone from the Dharmsala beds containing carbonaceous matter are under examination for microfossils. (Collection: Mr. G. Kohli.)

(8) Core samples of the Cuddalore lignite were received during the year from Dr. M. S. Krishnan, and microfloral studies

of the samples have been made. (Collection: Mr. R. N. P. Arogyaswamy.)

Some of the more important items of investigation initiated last year and continued during the year under review are mentioned below:

1. Cuticular study of certain Kamilaroi and Triassic plants of Australia, kindly loaned by the Director, Australian National Museum, Sydney.
2. Study of the microflora of the upper and lower seams of the Leigh Creek coalfield, South Australia.
3. Mesozoic plants from the Saighan series of Afghanistan.
4. Microspore investigation of the Intertrappean carbonaceous shales from Worli hill near Bombay.
5. Microfossil investigation of the Cuddalore lignite, South Arcot.

Rehabilitation work in the Museum

The work of reclassifying the important collection of Gondwana plant fossils in the Indian Museum taken up last year was continued. The old lables of specimens in most of the show cases were changed and the nomenclature brought up to date in the light of recent knowledge. Some of the type specimens of Gondwana plants damaged during the war period were restored. Others are under repair.

Donations

Small collections of plant fossils were presented to:

(1) The Saugor University, C.P., (2) The Principal, St. Xavier's College, Ranchi and (3) The Government of Himachal Pradesh.

Assistance given to post-graduate students and research workers

Published information on the Tertiary plants reported from the Himalayan region was made available to Dr. G. S. Puri, Ecologist, Forest Research Institute, Dehra Dun. At his request a small collection of Tertiary leaf impressions from that region was sent to him on loan for study.

At the request of Mr. N. N. Chatterjee, Department of Geology, Calcutta University, Mr. A. Chowdhury. was permitted to undergo training in palaeobotanical methods of investigation under Dr. Jacob.

Mr. R. N. Lakhanpal of the Palaeobotanical Institute visited the Department in connection with his investigation of a collection of Assam Tertiary plants.

Mr. Rao, Research Fellow, Botanical Survey of India, was given help regarding the fossil occurrence of the Tiliaceae in India in connection with his monograph on the genus *Grewia.*

Mr. A. Lahiri of the Fuel Research Institute who is investigating the microspores of the Gondwana coals came for consultation.

Assistance was given to Mr. S. K. Dey, Presidency College, Calcutta, in examining his small collection of plant fossils collected from the Burhai Gondwana basin.

The post-graduate students in Geology of the Calcutta University visited the department on several occasions and were given practical help in palaeobotany.

Publications

K. Jacob and N. K. N. Aiyengar.—A preliminary note on *Pseudocycadeoidea,* a new genus of plant fossils from the Cretaceous formation of the Trichinopoly district, South India. *Rec. Geol. Surv. Ind., Vol. 78, Pt. 2* (in the press).

K. Jacob.—Land connections between India and Ceylon: Symposium on the "Satpura Hypothesis". *Proc. Nat. Inst. Sci. Ind.* (in the press). This note was prepared at the request of Dr. S. L. Hora, Director, Zoological Survey of India.

A short illustrated account of the Gondwana and foreign collections of plant fossils in the Indian Museum was prepared at the request of the Honorary Secretary, Board of Trustees, the Indian Museum, for incorporation in their Museum Guide to be published shortly. At the request of the Museum Association of India, a short account was prepared on the palaeobotanical collections in the Indian Museum.

GEOPHYSICAL WORKSHOP

Dr. F. Ermisch has been in charge of the Geophysical Section since Dr. G. Dessau, the former Geophysicist-in-charge, left the Geological Survey of India in the middle of the year, at the expiry of his contract.

Mr. A. Del Carlo, Technician of the Geophysical Section, has been engaged in the workshop and laboratory attached to the Survey, in Calcutta, in making and improving a number of instruments and accessories for the equipment of the Section including the following :—

(1) Three sets of field equipment for resistivity measurements, complete with all accessories and telephone connections; (2) one set of small portable seismic equipment; (3) one well-water resistivity measuring set; (4) one set of alternating current investigation equipment; (5) several accessories for field work.

Three new machines have been installed in the workshop—a precision milling machine, an engraving machine and a photostat and several measuring and testing instruments have been added to the stock. Besides, theoretical curves for the interpretation of field resistivity measurements are in the course of preparation and will require some more time for completion.

DRAWING OFFICE

Mr. H. D. Sarkar was in charge of the Drawing Office throughout the year, except for a period of 19 days from 16th September 1948 to 4th October 1948 and for 22 days from 19th October 1948 to 9th November 1948 and for 4 days from 20th December 1948 to 23rd December 1948 when he was on leave.

Drawings.

During the year the preparation of geological (including mineral) maps, drawings, diagrams, charts, sections, publication drawings, lithographic drawings, graphs, text figures, etc., amounted to 1,250.

Issue of maps.

In the year under review 1,795 copies of topographical and geological maps in mounted and unmounted forms were issued to officers for use in the field.

Sale of maps.

The number of topographical maps received from the Director of Map Publication, Survey of India, totalled 13,439, while the number of new geological maps received from Departmental officers was 40.

Receipt of maps.

The number of published geological maps and that of hand coloured ones sold during the year were 1,315 and 348 respectively.

Block making.

During the year 202 blocks, both half-tone and line, were prepared.

Photography.

Photographic works undertaken during the year amounted to 2,254. These included general photography, photomicrography, developing, printing, enlarging and preparation of lantern slides.

The blue and ammonia printing executed during the year numbered 4,108.

Printing.

The total number of forms printed in the Drawing Office press amounted to 8,391. These included letter-press printing, printing of blocks and colour printing for the publications, labels for the Indian Museum, for touring officers and for office use, etc.

In addition to the above items of work a good deal of information regarding geological maps was supplied to the Central and Provincial Governments, to Indian States, to industrial concerns and to educational institutions.

MINERAL INFORMATION BUREAU

During the year under review the information service of the Geological Survey of India answered a larger number of enquiries than ever previously dealt with, the total number of enquiries received throughout the year amounting to 2,320 and averaging about 193 a month against a monthly average of 135 in 1947. In addition to requests for identification of minerals which involved petrological tests and chemical analyses, the enquiries received were chiefly in respect of various Indian minerals, fuels, iron-ore and ferro-alloy minerals, light and base metal minerals, precious metals, minerals for chemical industries, industrial clays, sands, etc. There were also enquiries regarding the availability of possible workable deposits of minerals such as asbestos, coal, limestone suitable for cement, ceramic material, gypsum, ilmenite, kyanite, monazite, quartz crystals, etc. In several instances information was sought for suitable markets for certain minerals produced in India. Increasing interest was also shown for information on the trade aspects, for current market prices of minerals, and arrangements were taken in hand to collect prices as far as possible direct from the leading mineral dealers throughout India. With the partition of India the supply position of certain minerals in the Indian Union was affected, and requests for alternative sources of supply from the consuming industries were received.

As usual, enquiries were also received regarding mineral concession questions from private parties and from the States. Enquiries relating to such matters as rents, royalties, lease-deeds, mining rules, etc., have also been dealt with.

To sum up, the year 1948 showed a marked increase in the activities of the Bureau, and it is anticipated that with the enunciation and implementation of the new mineral policy of the

Central and the Provincial Governments, there will be a greater demand on the activities of the Bureau in the collection and dissemination of useful information calculated to help in the industrial advancement of the country.

"Indian Minerals"

During the year under report two issues of Indian Minerals (Vol. I, Nos. 3 and 4) were published, and the two subsequent issues (Vol. II, Nos. 1 and 2) were sent to the press.

Dr. D. N. Wadia continued as Editor till his appointment as Geological Adviser in the Department of Scientific Research; thereafter the journal was edited at Calcutta by Mr. V. P. Sondhi, Deputy Director, Mineral Development with the assistance of Mr. S. N. Banerjee who was formally appointed Assistant Editor on the 1st July, 1948.

VII. ADMINISTRATION

DISPOSITION LIST

During the period under report the officers of the Department were employed as follows:—

STATES LIAISON OFFICER

DR. H. CROOKSHANK.—Investigated the mineral resources of various States of Himachal Pradesh, Patiala and East Punjab States Union, Rajasthan, Matsya Pradesh, Saurashtra and Madhya Bharat and returned to headquarters on the 11th April, 1948. Proceeded on leave preparatory to retirement for one year on the 1st May, 1948.

SUPERINTENDING GEOLOGISTS

MR. E. J. BRADSHAW.—On deputation to the Government of Burma.

DR. M. S. KRISHNAN.—Continued in charge of the Southern Circle and also of the Rare Minerals Section. Visited Delhi in connection with the organisation of the Indian Bureau of Mines. Attended the meeting of the Atomic Energy Board at Bombay. On leave from the 16th April to the 22nd July, 1948. Officiated as Director, Indian Bureau of Mines, from the 4th August, 1948 to the 26th September, 1948. Took over charge of the Southern Circle and the Rare Minerals Section as Superintending Geologist on the 27th September, 1948 and remained in charge until the 30th November, 1948. Appointed Director, Indian Bureau of Mines with effect from the 1st December, 1948.

DR. J. B. AUDEN.—Continued in charge of Engineering Geology and Ground Water Resources Division. Attended the Mahanadi Conference at Delhi. Visited Nepal regarding the siting of a seismograph station; Sambalpur to discuss with the Central, Waterpower Irrigation and Navigation Commission the question of manufacture of cement for the Hirakud dam; Simla to discuss the Damodar Valley Project and in connection with the Diesel Power House. Inspected several dam sites, *viz.*, the Marora dam-site and the Ramganga dam-site, Garhwal district; the exploratory tunnels, Kosi dam-site, Nepal; the

Hirakud dam-site, Orissa; the Tilaiya and the Konar dam-sites, Damodar Valley Corporation; the Punasa and the Harinphal dam-sites on the Narbada river; the Vaitarna dam-site and the Pipri dam-sites. Placed in charge of the Engineering Geology and Ground Water Division and left headquarters for Delhi on the 10th November, 1948 to attend a conference in the Ministry of Agriculture.

Mr. V. P. Sondhi.—Continued at headquarters as the Deputy Director (Mineral Development). Visited the gold mines at Lowa, Manbhum district and inspected the calc-tufa deposit in the Dehra Dun district and the work of the Coal Survey Party at Ondal, West Bengal. Visited the training camp at Jubbulpore and returned to headquarters on the 14th December, 1948.

Dr. P. K. Ghosh.—Remained at headquarters as the Deputy Director (Administration) throughout the year.

Dr. M. R. Sahni.—Placed in charge of the Western Circle and subsequently of the Northern Circle. Carried out geological survey of the Mirzapur district and detailed examination of the railway alignment between Chunar, Ahraura and Markundi. Inspected certain coal areas in the Hazaribagh district. Investigated the Sarju river dam-site. Examined the coal occurrences at Dehar and Kaphai, Suket State and the well-site at Nalapani, Dehra Dun district. Visited the dam-site for the proposed Mussoorie-Dehra Dun Hydro-Electric Works. Examined the Power House Site in Simla. Placed in charge of the Northern Circle and left for the field on the 6th November, 1948.

*Mr. A. M. N. Ghosh.—Continued in charge of the Central Circle. Examined the kaṇkar deposit at Mugma, Manbhum district, Bihar. Visited the Soil Research Institute centres at Sholapur, Bijapur and Poona. Examined a fire-clay quarry near Khinda and a China clay deposit near Chuhukitikra, Sambalpur district. Investigated the manganese occurrences in the area between Dungripali and Tamia, Central

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*Holding a substantive temporary post of Superintending Geologist, and a permanent post in the grade of Geologist.

Provinces. Examined the Bhandar limestones near Maihar, a well section for coal near Nagpur and some of the river and road sections around Raigarh. Visited sites for iron and steel works near Sambalpur and the Hirakud dam-site. Placed in charge of the Central Circle.

*DR. B. C. ROY.—Placed in charge of the Southern Circle. Examined the Ramapadasagar dam-site, East Godavari district and sub-soil water conditions and tube-well sites in the South Arcot district. Placed in charge of the Western Circle. Visited the Sambhar Lake and the Kharagoda Salt Works at Kathiawar. Examined the Bhoreghat tunnel; the Koyna dam-site; several dam sites in connection with the Kalinadi Project; the Vaitarna Project; the dam-sites across the Kapriwadi river for water supply in the Ahmednagar Cantonment area. Carried out geological survey in the Bijapur, Kolaba, Kaira and Surat districts. Returned to headquarters on the 30th April, 1948. Placed in charge of the Western Circle and left for the field on the 12th November, 1948.

*DR. A. K. DEY.—Placed in charge of the Eastern Circle. Examined sites for dams on the Dihang at Rengging, at Kangchup, north-west of Imphal and alignment for a channel to divert the surplus water of the Chakpi, a tributary of the Manipur river. Visited Digboi and other oil-fields of Assam and the copper workings in Sikkim. Examined the crystalline limestone occurrence near the Chhanggu Lake, Sikkim. Visited the Rokhia Test area (Burmah Oil Co.) and the clay occurrence at Champamura, Tripura State. Advised the Assam Government on the questions of leases and royalties in respect of sillimanite, coal, petroleum and natural gas. Placed in charge of the Eastern Circle and left for the field on the 29th November, 1948.

†DR. A. G. JHINGRAN.—Remained at headquarters as Petrologist until the 27th November, 1948. Placed in charge of the Southern Circle.

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* Holding a substantive temporary post of Superintending Geologist, and a permanent post in the grade of Geologist.

† Officiating as Superintending Geologist, and holding a permanent post in the grade of Geologist.

GEOLOGISTS

*MR. B. C. GUPTA.—Attached to the Mineral Development Section. Placed in charge of the Ceramic Raw Materials Investigation Party. Attached to the Mineral Development Division, Mineral Prospecting Section and left headquarters on the 15th November, 1948 to take charge of the training camp in the Central Provinces and Bihar.

†MR. P. N. MUKHERJEE.—Remained at headquarters as Palaeontologist throughout the year.

MR. A. B. DUTT.—Attached to the Northern Circle. Supervised the drilling operations in the Damodar river and resumed a detailed survey of the Bokaro Coalfield on the new 4″=one mile sheets. Attached to the Mineral Development Section and placed in charge of the Coal Survey Party to take up the investigation of coal suitable for the manufacture of synthetic oil. Returned to headquarters and appointed Petrologist with effect from the 27th November, 1948.

MR. P. C. DAS HAZRA.—Attached to the Engineering Geology and Ground Water Resources Division. Examined the Lalitpur dam-site, Jhansi district; weir sites on the Harrai, the Khajuri streams and at Nagwa, on the Karamnasha *nadi*, Mirzapur district; a new tunnel alignment of the Yamuna Hydro-electric Scheme; the Panchet hill dam-site; the Belpahri dam-site, Barakar river; the barrage site, Mor River Scheme; the Tilaiya and the Konar dam sites, Damodar Valley Project; the Dochi dam-site, Patiala State; and the Bhakra dam-site, East Punjab. Returned to headquarters on the 22nd July, 1948. Attached to the Engineering Geology and Ground Water Division and left for the field on the 17th November, 1948 for the examination of certain dam-sites in South India.

MR. V. R. R. KHEDKER.—Attached to the Eastern Circle. Remained at headquarters throughout the year to prepare a report on the mineral resources of the Damodar Valley and adjacent region and their utilisation for industrial development. Attached to the

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* Re-employed as a temporary Geologist after retirement on the 16th December, 1948.

† Re-employed as a temporary Geologist after retirement on the 6th December, 1948.

Mineral Development Division, Mineral Prospecting Section.

MR. N. K. N. AIYENGAR.—Attached to the Southern Circle. Carried out geological survey in the Salem district. Took charge of the Southern Circle Office during Dr. M. S. Krishnan's temporary absence from Madras. Remained at headquarters in Calcutta between the latter half of June and the first half of July for rearranging specimens in the Indian Museum. Returned to circle headquarters at Madras on the 18th July, 1948. Attached to the Southern Circle and left for the field on the 19th December, 1948.

MR. G. C. CHATERJI.—Attached to the Engineering Geology and Ground Water Resources Division. Examined rock outcrops in the Manbhum district and the Santhal Parganas in connection with the Damodar Valley Project. Inspected a bridge site on the Brahmani river and the bridge site No. IV on the Baitarani river. Carried out ground water investigation in the Hijli area. Examined township sites south-east of Betul; between the Bewas river and the Dhasan river and between Saugor and the Dhasan river, Central Provinces. Inspected tube well sites and other well sites at Bhubaneshwar. Inspected the Tapti river gorge, south-east of Betul; the Weinganga river dam-site; the Mettur dam-site; the Kannambadi dam-site on the Cauvery river; the Jog Falls on the Saraswaty river and the Tungabhadra dam-site, Bellary district. Returned to headquarters on the 2nd November, 1948. Attached to the Engineering Geology and Ground Water Division and left for the field on the 3rd December, 1948.

MR. M. S. VENKATRAM.—Attached to the Southern Circle. Carried out geological survey in the East and the West Godavari districts and in the Kurnool district. Examined the foundation excavation of, and some level spots near, the Tungabhadra dam-site and also the Siddeswaram dam-site. Held the charge of the Southern Circle Office between June and the middle of July, 1948. Accompanied the steel consultants to the Government of India to show them some manganese mines and select iron-ore deposits at Sandur. Attached to the Southern Circle.

DR. K. JACOB.—Remained at headquarters as Palæobotanist. On leave for 15 days with effect from the 4th August, 1948. Left for geological survey in the East and the West Godavari districts, Madras Presidency, on the 8th September, 1948 and returned to headquarters on the 8th October, 1948. Remained at headquarters as Palæobotanist for the rest of the year.

MR. K. K. DUTTA.—Attached to the Engineering Geology and Ground Water Resources Division. Examined various dam-sites, viz., the Konar dam-site, the Tilaiya dam-site, the Panchet hill dam-site, the Kosi dam-site in Nepal, the Mettur dam-site, the Kannambadi dam-site, the Jog Falls and the Tungabhadra dam-site, Madras. Transferred to the Mineral Development Section and carried out the investigation of the Lowa gold mines, Manbhum. Attached to the Engineering Geology and Ground Water Division. Left headquarters for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

MR. M. S. BALASUNDRAM.—Attached to the Engineering Geology and Ground Water Resources Division. Examined a number of dam and weir sites on the Tapti river in Baroda State, on the Narbada river in Rajpipla State, on the Indravati river in Bastar State; numerous bridge sites near the Rakha mines, B. N. Railway, near Maubhandar and Mosabani ferry crossing, at Ghatsila and on the Ranchi Plateau for the new railway alignment. Visited Bhikna Thoree on the border of Bihar and Nepal to study local geology and the reported occurrence of tufaceous limestone. Investigated gravel deposits for aggregate at Banbassa, near Bareilly, U.P., and source of water supply for the railway stations on the Ranchi Plateau. Returned to headquarters on the 2nd May, 1948 and left for provincial headquarters at Madras on the 2nd June, 1948. Attached to the Engineering Geology and Ground Water Division and left provincial headquarters on the 18th October, 1948 for the examination of certain dam sites in Madras Presidency.

MR. R. N. P. AROGYASWAMY.—Attached to the Mineral Development Division. Returned to headquarters from the

Training Camp on the 9th December, 1948. Investigated and estimated the vein quartz near Pandrasali; examined the limestone occurrence at Chaibasa; glass-sand occurrences in Bihar; the various rock types and the old copper workings and mines in and near Khetri, Jaipur State; Daribo copper mines, Alwar State; the China clay deposits of the Mayurbhanj State and the China clay and the kaolin deposits of the Keonjhar State. Investigated the Lowa Gold Mines, Manbhum. Attached to the Mineral Development Division, Mineral Prospecting Section and left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

MR. S. P. NAUTIYAL.—Attached to the Engineering Geology and Ground Water Resources Division. Examined various dam sites and bridge sites in the United Provinces and in Madras. Accompanied the High Altitude Observatory Expedition to the Central Himalayas in the Garhwal district in connection with the building of an astronomical station at an altitude between 14,000 and 16,000 feet above sea level. Visited hot springs near Topoban, the Joshimath—Chamoli motor road alignment, and the tunnel alignment through the spur between the Mandakini and the Alokananda rivers at Rudraprayag. Examined the Crosswaite Hospital Extension site and the land slip above Himanta Nivas, Naini Tal district. Attached to the Engineering Geology and Ground Water Division and left Calcutta for the circle office at Lucknow on the 5th November, 1948.

MR. P. K. CHATTERJEE.—Attached to the Central Circle. Visited the Sholapur Soil Research Institute and the Padegaon farm to study soil profiles and methods of soil conservation. Carried out geological survey in the Nagpur and the Chhindwara districts. Attached to the Central Circle and left headquarters for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

MR. S. KRISHNASWAMY.—Attached to the Central Circle. Carried out geological survey in the Sambalpur district. Investigated the manganese occurrences in the Patna and Rairakhol States, Orissa and visited the manganese mines near Vizianagram, Madras. Visited the Konarak and Jambo areas to select suitable sites for water prospecting by electrical method, and the coastal tract between Balasore and Cuttack for selecting tube-well sites. Examined a well-site near Khurda Road railway station, B. N. Railway. Recessed at the provincial headquarters at Madras from June, 1948. Attached to the Southern Circle and left for the field on the 10th December, 1948.

MR. V. SUBRAMANYAM.—Attached to the Engineering Geology and Ground Water Resources Division. Examined the Ramapadasagar dam-site, Godavari district and carried out a hydrological survey of the Palladam taluk, Coimbatore district. Investigated a gypsum occurrence in the Coimbatore district and a limestone deposit in the East Godavari district. Recessed at provincial headquarters at Madras from July to October, 1948. Attached to the Engineering Geology and Ground Water Division and left headquarters on the 10th December, 1948 to take up hydrographic survey in the Ceded districts.

MR. P. K. GHOSH.—Remained at headquarters as Curator till the end of March. Attached to the Northern Circle and carried out geological survey in the Damodar river area. Subsequently attached to the Mineral Development Section, Coal Survey Party. Carried out geological mapping and detailed sampling in several coal areas in the Hazaribagh district. Attached to the Mineral Development Division, Mineral Prospecting Section. Left headquarters for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

‡MR. C. KARUNAKARAN.—Remained at headquarters until the 9th November, 1948. Attached to the Western Circle and left headquarters on the 10th November, 1948 for geological mapping in Ajmer-Merwara.

‡MR. M. C. PODDAR.—Remained at headquarters. Attached to the Western Circle and left headquarters on the 7th

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‡ Government orders with regard to his confirmation and seniority *vis-a-vis* other geologists will be issued on his satisfactorily completing 2 years service.

November. 1948 for geological survey in Baroda, Saurashtra and Cutch States.

*MR. D. R. S. MEHTA.—Attached to the Mineral Development Section. Carried out investigation of glass-making sands in the Banda district, United Provinces, and in Rewa State; of quartz and felspar deposits near Kodarma; of fire-clay deposits in the Bokaro coalfield; and gypsum deposits in Kathiawar. Returned to headquarters on the 12th May, 1948 and recessed at Calcutta until the end of October. On leave for 36 days with effect from the 1st September, 1948. Attached to the Mineral Development Division, Mineral Prospecting Section and left headquarters for field on the 30th October, 1948.

†DR. T. C. BAGCHI.—Remained at headquarters until the beginning of the next field season. Attached to the Central Circle and left headquarters on the 10th December, 1948, for geological work in Orissa.

GEOPHYSICISTS

[1]DR. G. DESSAU.—Continued in charge of the Geophysical Section. Visited Kosi dam area together with the officers of the Meteorological Department and the Central Water-power, Irrigation and Navigation Commission for fixing location of seismic observatories; and the copper deposits of Sikkim for considering the advisability of geophysical survey for their exploration. Returned to headquarters at Calcutta on the 23rd April, 1948 and remained there until the contract of his appointment terminated on the 9th July, 1948.

[1]DR. F. ERMISCH.—Attached to the Geophysical Section. Directed geophysical work and investigation for water in Jodhpur State. Inspected magnetic and electrical surveys for manganese at Tirodi, Central Provinces and electrical survey at Dhond, Poona. Took over charge of the Geophysical Section on the 9th July, 1948. Proceeded on leave out of India for 92 days with effect from the 14th August, 1948.

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* Holding a temporary post of Geologist, but a permanent post in the grade of Assistant Geologist.

†Holding a temporary post.

[1] On contract service.

PETROLEUM GEOLOGIST

*MR. V. H. BOILEAU.—Visited the Digboi oilfield and the test areas of the Burmah Oil Co. in Assam. Examined the rocks in the Jawalamukhi area, Kangra district. Visited the clay occurrence near Agartala, Tripura State. Examined the coastal outcrops and oil indications in various places in Cutch State. Returned to headquarters on the 19th December, 1948.

CHEMISTS

DR. R. K. DUTTA ROY.—Remained at headquarters throughout the year.

† DR. V. T. ATHAVALE.—Attached to the Rare Minerals Section.

MINING ENGINEER

*MR. D. KERR-CROSS.—In charge of the Mining Section. Investigated the copper deposits in Sikkim, and visited the properties of the Indian Copper Corporation at Ghatsila. Examined the gold mines at Lowa, Manbhum district; the pyrites deposit of Messrs. Kuchwar Lime & Stone Co., at Amjor, Shahabad district, Bihar and the gypsum deposit at Bharli, Sirmur State. In charge of the Mining Section.

DEPUTY MINING ENGINEER

[1]MR. G. V. UPADHYAYA.—Attached to the Mining Section. On leave for 41 days with effect from the 1st March, 1948. Carried out investigation of calc-tufa deposits in the Dehra Dun district and of gypsum deposits in Sirmur State. Attached to the Mining Section.

ASSISTANT GEOLOGISTS

MR. D. GUPTA.—Attached to the Eastern Circle. Examined the Ironstone Shale Measures near Barakar and Kulti to estimate the reserves of the shale. Visited the Lakhimpur district, Assam, to collect samples of heavy sand. Returned to headquarters on the 18th May, 1948 and acted as Curator. On leave for 15 days with effect from the 29th December, 1947

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* On contract service.

† Holding a temporary post.

[1] Holding a substantive temporary post.

and for one month and 29 days with effect from the 2nd August, 1948. Attached to the Rare Minerals Section.

MR B. G. DESHPANDE.—Attached to the Western Circle. Examined the village water supply problems in the Nasik and Poona districts and the tube-well irrigation possibilties in the Khaira district. Examined the Bhore Ghat Tunnel No. 23, Kolaba district, and the reported coal occurrence near Dhulia, West Khandesh district. Attached to the Western Circle and left provincial headquarters for field work on the 30th November, 1948.

MR. S. NARAYANASWAMI.—Attached to the Southern Circle. Carried out geological survey in the Tinnevelley and the Ramnad districts. Attached to the Southern Circle and left provincial headquarters for the Training Camp in the Central Provinces and Bihar on the 14th November, 1948.

MR. D. K. CHANDRA.—Attached to the Eastern Circle. Examined the limestone occurrences in the Nowgong and the Sibsagar districts. Visited Siliguri to locate sources of ballast and aggregate for the Assam Rail Link project. Visited Tatanagar to bring samples of raw materials used by Messrs. Tata Iron and Steel Co. Ltd. Attached to the Eastern Circle and left headquarters on the 7th November, 1948 for field work in Assam.

MR. M. K. ROY CHOWDHURY.—Attached to the Central Circle. Carried out geological survey in Datia State and in Balaghat, Central Provinces. Returned to headquarters on the 25th April, 1948. On leave for 15 days with effect from the 1st June, 1948. Attached to the Central Circle and left headquarters on the 10th November, 1948 for field work in the Central Provinces.

MR. G. N. DUTT.—Attached to the Geophysical Section. Carried out geophysical prospecting and geological survey in Jodhpur State. Returned to headquarters on the 15th April, 1948. Attached to the Mineral Development Division, Coal Survey Party. Carried out explorations in various coalfields in the Burdwan and the Hazaribagh districts in connection with the investigation of coal suitable for the manufacture of synthetic oil. Returned to headquarters on the 25th July, 1948. Attached to the Northern Circle and left headquarters on the 10th November, 1948 for field work in Tehri-Garhwal State.

MR. A. P. SUBRAMANIAM.—Attached to the Southern Circle. Investigated certain clay deposits in the East and the West Godavari districts. Carried out geological survey in the Salem, the Trichinopoly and the Coimbatore districts. Returned to the Circle headquarters at Madras on the 4th May, 1948. Attached to the Southern Circle and left headquarters on the 4th December, 1948 for field work in the Trichinopoly and the Salem districts.

MR. MUKTI NATH.—Attached to the Northern Circle. Examined the Kajrahat limestone deposit in the Mirzapur district and investigated the gypsum deposits in Sirmur State. Returned to headquarters on the 10th May, 1948. Attached to the Mineral Development Division, Mineral Prospecting Section and left headquarters on the 9th October, 1948 for field work in the Almora district.

MR. F. AHMAD.—Attached to the Northern Circle. Carried out investigation in connection with the Rihand dam-site, and geological survey in the Mirzapur district. Returned to headquarters on the 29th May, 1948. On leave for 29 days with effect from the 25th September, 1948. Attached to the Northern Circle and left headquarters on the 3rd November, 1948 for field work in the United Provinces.

MR. A. K. BELGAUMI.—Attached to the Southern Circle. Carried out exploratory work for road metal in the Malabar district and material for cement concrete in the Coimbatore district. Returned to provincial headquarters at Madras on the 4th June, 1948. On leave for 12 days with effect from the 19th October, 1948. Attached to the Southern Circle and left for field work in the Malabar district on the 4th December, 1948.

MR. A. K. ROY.—Attached to the Central Circle. Investigated water supply resources in various districts in the Central Provinces, *viz.*, Amraoti, Akola, Buldana, Nagpur, Wardah, Chanda, Chhindwara, Jubbulpore, Saugor, Bilaspur, Raipur, Drug, Balaghat and Bhandara. Recessed at provincial headquarters at Nagpur from the 3rd May to the 10th September, 1948. Returned to Calcutta on the 11th September, 1948. Attached to the Engineering Geology and Ground Water Division and left for Nagpur on the 10th November, 1948.

MR. S. N. SEN.—Attached to the Southern Circle. Carried out geological survey in the Guntur and Nellore districts. Returned to headquarters on the 4th May, 1948. Appointed Curator from early August and remained at headquarters for the rest of the year.

MR. S. C CHAKRAVARTY.—Attached to the Geophysical Section. Carried out geological survey in connection with the geophysical exploration for graphite in Athmallik State. Returned to headquarters on the 3rd April, 1948. On leave for 51 days with effect from the 15th April, 1948. Attached to the Central Circle and left headquarters on the 12th November, 1948 for field work in Orissa.

MR. V. S KRISHNASWAMY.—Attached to the Engineering Geology and Ground Water Resources Division. Posted at Sambalpur to carry out geological investigations at the Hirakud dam-site. On leave for 36 days with effect from the 31st May, 1948 and for 37 days with effect from the 1st September, 1948. Resumed duty at Sambalpur on the 8th October, 1948 and attached to the Engineering Geology and Ground Water Division.

MR. B. F. MEHTA.—Attached to the Western Circle. Carried out geological survey in the Bijapur district, Bombay. Returned to provincial headquarters at Bombay on the 29th April, 1948. Attached to the Western Circle and left for field work in the Belgaum district on the 9th November, 1948.

MR. K. D. SHUKLA.—Attached to the Mineral Development Division. Carried out geological investigations for ceramic raw materials in the Jubbulpore, Hoshangabad and Chhindwara districts and for coal in the Hazaribagh district. Returned to headquarters on the 31st July, 1948. Attached to the Mineral Development Division, Mineral Prospecting Section and left headquarters on the 20th November, 1948 for field work in the Central Provinces.

MR. B. LASKAR.—Attached to the Eastern Circle. Carried out mineral investigations in the Garo hills. Returned to headquarters on the 26th May, 1948. On leave for 11 days with effect from the 31st May, 1948. Attached to the Eastern Circle and left headquarters on the 2nd December, 1948 for field work in Assam

MR B. N SINHA.—Attached to the Western Circle. Carried out geological survey in Ajmer-Merwara. Returned to provincial headquarters in Bombay on the 7th May, 1948. Recessed at headquarters at Calcutta from 22nd May, 1948 and proceeded to the U. S. A. on leave with effect from the 18th August, 1948 for further study.

*MR G. H. S. V. PRASADA RAO.—Attached to the Central Circle. Carried out mineral and water supply investigations in the Ganjam and the Koraput districts, Orissa. Returned to provincial headquarters at Puri on the 21st May, 1948. On leave for 11 days with effect from the 11th August, 1948. Attached to the Central Circle and left for field work in Orissa on the 14th November, 1948.

*MR. S. M. MATHUR.—Attached to the Central Circle. Carried out geological and mineral survey in the Amraoti, Chanda and Raigarh districts, Central Provinces. Returned to provincial headquarters at Nagpur on the 12th May, 1948. Attached to the Central Circle and left for field work in the Central Provinces and Berar on the 17th November, 1948.

MR. K NARAIN.—Attached to the Central Circle. Carried out geological survey in the Sambalpur district. Examined a fire-clay band near Khinda and China clay occurrence near Chuhukitikra. Visited tube-well sites in the Balasore and Cuttack districts. Returned to provincial headquarters at Puri on the 6th May, 1948. On leave for 25 days with effect from the 15th May, 1948. Attached to the Northern Circle and left headquarters for field work in Bihar on the 1st November, 1948.

MR. N. A. VEMBAN—Remained at headquarters as Assistant Petrologist throughout the year excepting from the

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* On probation.

7th June to the 22nd July 1948 during which period he was on leave.

MR. G. KOHLI.—Attached to the Northern Circle. Carried out geological survey in the Mirzapur and the Kangra districts, and investigations in connection with the Rihand dam-site. On leave for 64 days with effect from the 7th February, 1948. Examined the coal occurrences in Suket State and the iron-ore bearing rocks in the Palanpur district. Returned to headquarters on the 9th July, 1948. Attached to the Northern Circle and left for field work in the East Punjab on the 16th October, 1948.

*MR. K. S. MAHAPATRA.—Attached to the Mining Section. Carried out examinations of the copper deposits at Khetri, Jaipur State, the lead-zinc mines at Zawar, Mewar State and the Daribo copper deposits, Alwar State. Investigated the gypsum deposits in Sirmur State. Assisted in the boring operations and carried out other exploratory works in the various collieries in Burdwan district. Returned to headquarters on the 12th July, 1948. Attached to the Mineral Development Division, Mining Section. On leave for 36 days with effect from the 11th December, 1948.

MR. Y. G. KRISHNAMURTHY.—Attached to the Central Circle. Carried out geological survey and water supply investigations in the Ganjam and the Koraput districts. Returned to circle headquarters at Puri on the 22nd May, 1948. On leave for 17 days with effect from the 7th June, 1948. Attached to the Central Circle and left for field work in Orissa on the 17th November, 1948.

MR. K. BALU.—Attached to the Northern Circle. Carried out geological mapping in certain coal fields in the Manbhum and Hazaribagh districts. Returned to headquarters on the 20th May, 1948 Attached to the Southern Circle and left Circle headquarters at Madras for field on the 1st December, 1948.

*MR. C. RAMASWAMY.—Attached to the Southern Circle. Carried out geological mapping in the East and the West Godavari districts. Returned to Circle headquarters at Madras on the 26th May, 1948. Attached

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* On probation.

to the Southern Circle and left for field work in Madras on the 1st December, 1948.

*Mr. T K. Kurien.—Attached to the Western Circle. Carried out geological mapping in Ajmer-Merwara. Returned to Circle headquarters at Bombay on the 7th May, 1948. Attached to the Western Circle and left for field work in Ajmer-Merwara on the 4th December. 1948.

*Mr. N. V. Chandrasekariah.—Attached to the Southern Circle. Carried out geological mapping in the Guntur district. Returned to Circle headquarters at Madras on the 4th May, 1948. On leave for 19 days with effect from the 19th October, 1948. Attached to the Southern Circle and left for field work in Madras on the 30th November, 1948.

*Mr. Md. Ziauddin.—Attached to the Southern Circle. Carried out geological mapping in the West Godavari district. Returned to circle headquarters at Madras on the 4th May, 1948. On leave for 20 days with effect from the 24th June, 1948. Attached to the Southern Circle, and left for field work in Madras on the 1st December, 1948.

*Mr. M. V. A. Sastry.—Posted at headquarters as Assistant Palæontologist. On leave for 30 days with effect from the 19th October, 1948. Resumed duties on the 18th November, 1948 and remained at headquarters as Assistant Palæontologist for the rest of the year.

*Mr. D. M. Sen.—Attached to the Drilling Section. In charge of drilling for sand in the Damodar, Barakar and Ajay rivers, and assisted in boring for coal in the Burdwan district. Returned to headquarters on the 30th June. 1948. Attached to the Drilling Section and left headquarters for field work in the Burdwan district on the 29th October, 1948.

Mr. R. Thiagarajan.—Attached to the Southern Circle. Carried out geological survey in the Anantapur district and an examination of clays for the ceramic industry in the Kurnool, Anantapur and Bellary districts. Returned to Circle headquarters at Madras on the 30th April, 1948. Attached to the Mineral Development Division, Rare Minerals Section and left for

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* On probation.

the investigation of a barytes deposit in the Nellore district on the 11th December, 1948.

MR. N. V. B. S. DUTT.—Attached to the Southern Circle. Carried out geological survey in the Anantapur, Kurnool and Cuddapah districts. Returned to Circle headquarters at Madras on the 2nd May, 1948. Attached to the Southern Circle and left for field work in the Kurnool district on the 28th November, 1948.

*MR. A. S. RAMIENGAR.—Attached to the Southern Circle. Carried out geological survey in the Salem district. Returned to circle headquarters at Madras on the 14th May, 1948. On leave for 17 days with effect from the 19th October, 1948. Attached to the Southern Circle and left for field work in the Salem district on the 8th December, 1948.

*MR. J. NARAYANAMURTHY.—Attached to the Southern Circle. Carried out geological mapping in the Tinnevelly district. Returned to Circle headquarters at Madras on the 3rd May, 1948. On leave for 12 days with effect from the 19th October, 1948. Attached to the Southern Circle and left for field work in the Kurnool district on the 27th December, 1948.

*MR. T. BANERJEE.—Attached to the Eastern Circle. Carried out geological mapping in the Abor hills. Examined a coal occurrence in the Sibsagar district and a limestone occurrence in Manipur State. Carried out an investigation of the water supply position in Manipur State. Reported occurrences of soil containing limonite, and of calcareous slates and of limestone bands in Manipur State. Returned to headquarters on the 6th May, 1948. On leave for 11 days with effect from the 19th July, 1948. Attached to the Eastern Circle and left headquarters for field work in Assam on the 7th November, 1948.

†MR. M. A. ANANDALWAR.—Attached to the Geophysical Section Carried out electrical and seismic survey on the Brahmaputra river bed at Jogigopa, Goalpara district, Assam, and geophysical investigation in Jodhpur State. On leave for 38 days with effect from the 3rd June, 1948. Attached to the Geophysical

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* On probation.

†Holding a temporary post.

Section and resumed geophysical investigation in Jodhpur State.

†MR. V. VENKATESH.—Attached to the Southern Circle. Carried out geological survey in the Kurnool district. Returned to Circle headquarters at Madras on the 9th May, 1948. Attached to the Southern Circle and left for field work in the Kurnool district on the 3rd December, 1948.

†MR. B. SRIKANTAN.—Attached to the Southern Circle. Carried out geological survey in the Chittoor and North Arcot districts. Returned to circle headquarters at Madras on the 26th April, 1948. Attached to the Southern Circle.

†MR. M. N. DEEKSHITULU.—Attached to the Central Circle. Carried out investigation for road metal in the Sambalpur and Cuttack districts and search for fire-clay and glass sand in Talchir State. Returned to headquarters on the 12th June, 1948. Attached to the Central Circle and left Circle headquarters for field work in the Cuttack district.

†MR. G. G. K. SASTRI.—Attached to the Mineral Development Division. Investigated fire-clay occurrences associated with the coal seams in the Hazaribagh and Ranchi districts, and the gypsum deposits in Kathiawar and Cutch State. Returned to headquarters on the 1st June, 1948. Attached to the Mineral Development Division, Mineral Prospecting Section. Proceeded from circle headquarters at Madras on the 2nd December, 1948 to Jodhpur State to take up the investigation of gypsum.

†MR. K. C. CHANNABASAPPA.—Attached to the Western Circle Investigated the rural water supply problems in the coastal belts of the Surat and Broach districts. Returned to Circle headquarters at Bombay on the 29th February, 1948. On leave for 3 months with effect from the 8th March, 1948. Attached to the Western Circle and left for field work in the Belgaum district on the 3rd November, 1948.

†MR. G. V. RAO.—Attached to the Central Circle. Carried out geological survey and mineral investigations in Maihar State, Central India. Returned to head-

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†Holding a temporary post.

quarters on the 30th April, 1948. Attached to the Central Circle and left headquarters for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

†Mr. V. Gopal.—Attached to the Southern Circle. Carried out geological mapping in the Tinnevelly and the Ramnad districts. Returned to Circle headquarters in Madras on the 3rd May, 1948. Attached to the Southern Circle. Arrived at headquarters in Calcutta on the 12th November, 1948 and left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

†Mr. R. K. Sundaram.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

†Mr. J. P. Srivastava.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*Mr. M. Krishnamurthy.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*Mr. S. N. Singh.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*Mr. D. K. Chatterjee.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*Mr. C. S. Raja Rao.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*Mr. S. K. Ramaswamy.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*Mr. C. K. R. K. Sastry.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*Mr. A. Damodaran.—Attached to the Engineering Geology and Ground Water Resources Division. Carried out geological reconnaissance survey at the Ramganga dam-site and also inspection of tunnels at the Marora dam-site, Garhwal district. Attached to the

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*Officiating as Assistant Geologist.

†Holding a temporary post.

Engineering Geology and Ground Water Division. Returned to headquarters on the 10th November, 1948 and left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*MR. B. N. RAINA.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*MR. C. GOURISHANKAR.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*MR. A. L. SINGHA HUNDAY.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*MR. S. C. AWASTHI.—Attached to the Engineering Geology and Ground Water Resources Division. Carried out geological work at the Rihand dam-site, United Provinces and routine investigations at the Kosi dam-site, Nepal. Returned to headquarters in the middle of June, 1948. Attached to the Engineering Geology and Ground Water Division and left for field work in the United Provinces on the 11th November, 1948.

*MR. A. MITRA.—Attached to the Engineering Geology and Ground Water Resources Division. Carried out geological work at the Punasa dam-site and at Saugor, Central Provinces and at the Harinphal dam-site, Central India. Returned to headquarters on the 10th June, 1948. Attached to the Engineering Geology and Ground Water Division and left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*MR. N. VENKATAPPYYA.—Attached to the Mineral Development Division, Coal Survey Party. Carried out geological mapping and sampling in certain coalfields in the Hazaribagh district. Returned to headquarters at the end of July, 1948. Attached to the Rare Minerals Section and left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*MR. N GOPALA KRISHNAMURTHY.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

* Officiating as Assistant Geologist.

*MR. S. N. PURI.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*MR. T. MADHUSUDHANA RAO.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*MR. Y. S. SAHASRABUDHE.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*MR. D. N. SETT.—Remained on deputation to the Central Ground Water Organisation throughout the year.

*MR. D. VENKATARAMANAN.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*MR. V. R. VENKOBA RAO.—Left for the Training Camp in the Central Provinces and Bihar on the 15th November, 1948.

*MR. R. A. NAGARAJAIAH.—Attached to the Geophysical Section. Carried out magnetic and electrical survey for manganese-ore at Tirodi in the Balaghat district, Central Provinces. Returned to headquarters on the 22nd October, 1948. Attached to the Geophysical Section.

ASSISTANT GEOPHYSICIST

†DR. S. L. BANERJEE.—Attached to the Geophysical Section. Inspected magnetic survey of manganese-ore at Tirodi, Central Provinces. Returned to headquarters on the 14th September, 1948. Attached to the Geophysical Section and left for the field on the 3rd November, 1948.

GEOPHYSICAL TECHNICIAN

[1]MR. A. DEL CARLO.—At headquarters.

ASSISTANT CHEMISTS

MR. P. C. ROY.—At headquarters. On leave for two months with effect from the 2nd November, 1948.

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* Officiating as Assistant Geologist.

†Holding a temporary post.

[1] On contract service.

MR. R. B. GHOSH.—At headquarters. Attached to the field laboratory for coal analysis at Ondal, Bihar, during the period from the 12th May to the 24th July, 1948.

MR. B. N. SEN.—At headquarters.

*MR. M. K. DEY.—At headquarters.

*MR. P. D. MALHOTRA.—At headquarters. Left headquarters for work at the field laboratory in Sirmur State on the 8th December, 1948.

†MR. N. C. DAS.—At headquarters.

†MR. S. C. CHAKRAVARTY.—At headquarters.

†MR. K. M. GHOSH.—At headquarters. Attached to the field laboratory for analysis of gypsum in Sirmur State between the end of February and early June, 1948.

†MR. A. K. MAZUMDAR.—At headquarters.

REGISTRAR

MR. MANOMOHAN GHOSE.—At headquarters. On leave for 31 days with effect from the 5th November, 1948.

DRAWING OFFICE SUPERINTENDENT

MR. H. D. SARKAR.—Remained at headquarters. On leave for 19 days with effect from the 16th September, 1948, for 22 days with effect from the 19th October, 1948 and for 4 days with effect from the 20th December, 1948.

GEOLOGICAL ASSISTANTS

MR. B. D. TEWARI.—At headquarters.

MR. G. L. WAKHALOO.—At headquarters. On leave for 29 days with effect from the 24th June, 1948.

MR. K. NARAYAN PRASAD.—Carried out geological work in the East Coast, Madras. On leave for 15 days with effect from the 19th October, 1948.

MR. B. K. BAWEJA.—Carried out geological work in connection with the Rihand and the Pipri dam-sites, United Provinces and the Nangal and Bhakra projects, East Punjab.

MR. R. B. GUPTE.—Carried out geological work at the Hirakud dam-site, Orissa. Resigned from service with effect from the 11th May, 1948.

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* On probation.

† Holding a temporary post.

MR. S. K. BASU.—Carried out geological work at the Kalagarh and the Marora dam-sites, United Provinces.

MR. M. S. JAIN.—Carried out geological work in the Ramganga. the Marora, the Pipri and the Rihand dam-sites, United Provinces.

MR. M. C. BASU.—Carried out geological work at the Hirakud dam-site, Orissa.

MR. A. K. SAHA.—At headquarters.

MR. V. RAGHAVENDRA RAO.—At headquarters. On leave for 3 days with effect from the 4th October, 1948.

MR. B. N. JAYARAM.—At headquarters.

MR. B. R. CHELUVA IYENGAR.—At headquarters. On leave for 3 days with effect from the 4th October, 1948.

MR. C. J. R. VARAPRASADA RAO.—At headquarters. On leave for 3 days with effect from the 4th October, 1948.

MR. K. K. CHOPRA.—At headquarters.

MR. D. P. BAHL.—At headquarters. On leave for 2 days with effect from the 5th October, 1943.

GEOPHYSICAL ASSISTANTS

MR. L. N. KAILASAM.—Carried out geophysical work at Jogigopa, Goalpara district, Assam.

MR. A. C. DE.—Carried out geophysical work in Jodhpur State. Reverted to the Indian Meteorological Department, New Delhi, with effect from the 24th February, 1948.

MR. A. ROY.—Carried out geophysical work at Tirodi, Balaghat district, Central Provinces and at Dhond, Poona district, Bombay. Attended the Training Camp in the Central Provinces and Bihar.

MR. S. N. SEN GUPTA.—Carried out geophysical work at Dhond, Poona district, Bombay, and at Tirodi, Balaghat district, Central Provinces.

MR. P. C. PAL.—Carried out geophysical work at Kamptee and at Tirodi, Central Provinces and in Athmallik State, Orissa.

MRS. K. SARMA.—At headquarters. Accompanied the Geophysicist to Jogigopa, Goalpara district, Assam.

MR. P. M. MATHEW.—Carried out geophysical work at Jogigopa, Goalpara district, Assam, and in Jodhpur State. On leave for 14 days with effect from the 23rd August, 1948.

Technical Assistants

Mr. Ch. Narasimha Rao.—Carried out geological work at Ondal, Burdwan district, in connection with the investigation of coal suitable for the manufacture of synthetic oil.

Mr. S. K. Das Gupta.—At headquarters.

Mr. C. Suri Sastry.—At headquarters. Resigned from service with effect from the 14th December, 1948.

Driller

Mr. N. Mariano.—Attached to the Coal Survey Party engaged in the investigation of coal suitable for the manufacture of synthetic oil. Carried out drilling operations in the eastern part of the Raniganj Coalfield.

Drilling Assistant

Mr. P. N. Ghosh.—Attached to the Drilling Party engaged in the investigation of sand in the Damodar, Barakar and Ajay rivers included within the Raniganj Coalfield.

The sanctioned gazetted cadre of the Department at the end of the year consisted of 9 Superintending Geologists, 1 Mining Engineer, 1 Drilling Engineer, 2 Geophysicists, 31 Geologists, 1 Petroleum Geologist, 2 Chemists, 1 Physicist, 1 Deputy Mining Engineer, 1 Geophysical Technician, 72 Assistant Geologists, 1 Assistant Geophysicist, 9 Assistant Chemists and 1 Registrar.

Two posts of Superintending Geologist, 9 posts of Geologist, 1 post of Geophysicist, 1 post of Physicist, 1 post of Drilling Engineer and 4 posts of Assistant Geologist remained unfilled.

ADMINISTRATIVE CHANGES

Dr. A. G. Jhingran was promoted to officiate as Superintending Geologist with effect from the afternoon of the 27th November, 1948.

Promotions.

Dr. K. Jacob was promoted to a temporary post of Geologist with effect from the 30th March, 1948.

Mr. K. K. Dutta was promoted to a temporary post of Geologist with effect from the 30th March, 1948.

Mr. M. S. Balasundaram was promoted to a temporary post of Geologist with effect from the 30th March, 1948.

Mr. R. N. P. Arogyaswamy was promoted to a temporary post of Geologist with effect from the 30th March. 1948.

Mr. S. P. Nautiyal was promoted to a temporary post of Geologist with effect from the 30th March, 1948.

Mr. P. K Chatterjee was promoted to a temporary post of Geologist with effect from the 30th March, 1948.

Mr. V. Subramanyam was promoted to a temporary post of Geologist with effect from the 30th March, 1948.

Mr. P. K. Ghosh was promoted to a temporary post of Geologist with effect from the 30th March. 1948.

Mr. D. R. S. Mehta was promoted to a temporary post of Geologist with effect from the 30th March, 1948.

Mr. A. Damodaran was promoted to officiate as Assistant Geologist with effect from the 8th October, 1948.

Mr. S. C. Awasthi was promoted to officiate as Assistant Geologist with effect from the 8th October, 1948.

Mr. A. Mitra was promoted to officiate as Assistant Geologist with effect from the 8th October, 1948.

Mr. N. Venkatappayya was promoted to officiate as Assistant Geologist with effect from the 8th October, 1948.

Confirmations.

Dr. J. B. Auden was confirmed in his appointment as Superintending Geologist on the 1st May, 1948.

Mr. V. P. Sondhi was confirmed in his appointment as Superintending Geologist on the 9th November, 1948.

Dr. P. K. Ghosh was confirmed in his appointment as Superintending Geologist on the 9th November, 1948.

Dr. M. R. Sahni was confirmed in his appointment as Superintending Geologist on the 9th November, 1948.

Mr. V. R. R. Khedker was confirmed in his appointment as Geologist on the 1st May, 1948.

Mr. N. K. N. Aiyengar was confirmed in his appointment as Geologist on the 9th November, 1948.

Mr. G. C. Chatterji was confirmed in his appointment as Geologist on 9th November, 1948.

Mr. M. S. Venkatram was confirmed in his appointment as Geologist on the 9th November, 1948.

Dr. K. Jacob was confirmed in his appointment as Geologist on the 9th November, 1948.

Mr. K. K. Dutta was confirmed in his appointment as Geologist on the 9th November, 1948.

Mr. M. S Balasundaram was confirmed in his appointment as Geologist on the 9th November, 1948.

Mr. R. N. P. Arogyaswamy was confirmed in his appointment as Geologist on the 9th November, 1948.

Mr. S. P. Nautiyal was confirmed in his appointment as Geologist on the 9th November, 1948.

Mr. P. K. Chatterjee was confirmed in his appointment as Geologist on the 9th November, 1948.

Mr. S. Krishnaswamy was confirmed in his appointment as Geologist on the 9th November, 1948.

Mr. V. Subramanyam was confirmed in his appointment as Geologist on the 6th December, 1948.

Mr. P. K. Ghosh was confirmed in his appointment as Geologist on the 16th December, 1948.

Mr. A. K. Belgaumi was confirmed in his appointment as Assistant Geologist on the 11th November, 1948.

Mr. V. S. Krishnaswamy was confirmed in his appointment as Assistant Geologist on the 13th March, 1948.

Mr. K. D. Shukla was confirmed in his appointment as Assistant Geologist on the 13th August, 1948.

Mr. B. Laskar was confirmed in his appointment as Assistant Geologist on the 31st July, 1948.

Mr. B. N. Sinha was confirmed in his appointment as Assistant Geologist on the 2nd July, 1948.

Mr. N. A. Vemban was confirmed in his appointment as Assistant Geologist on the 24th July, 1948.

Mr. Y. G. Krishnamurthy was confirmed in his appointment as Assistant Geologist on the 4th September, 1948 (A. N.).

Mr. K. Balu was confirmed in his appointment as Assistant Geologist on the 6th July, 1948.

Mr. N. V. B. S. Dutt was confirmed in his appointment as Assistant Geologist on the 4th September, 1948 (A. N.).

Mr. R. B. Ghosh was confirmed in his appointment as Assistant Chemist on the 9th November, 1948.

Mr. B. N. Sen was confirmed in his appointment as Assistant Chemist on the 9th November, 1948.

Appointments.

Mr. D. Kerr Cross was appointed temporary Mining Engineer on contract for 5 years with effect from the 11th March, 1948.

Mr. A. B. Dutt was appointed Petrologist with effect from the 27th November, 1948.

Mr. C. Karunakaran was appointed temporary Geologist with effect from the afternoon of the 29th June, 1948.

Mr. M. C. Poddar was appointed temporary Geologist with effect from the afternoon of the 27th April, 1948.

Dr. T. C. Bagchi was appointed temporary Geologist with effect from the 28th September, 1948.

Mr. S. N. Sen was appointed Curator with effect from the 2nd August, 1948.

Mr. R. K. Sundaram was appointed temporary Assistant Geologist with effect from the 11th November, 1948.

Mr. J. P. Srivastava was appointed temporary Assistant Geologist with effect from the afternoon of the 25th October, 1948.

Mr. M. Krishnamurthy was appointed temporary Assistant Geologist with effect from the 2nd November, 1948.

Mr. S. N. Singh was appointed temporary Assistant Geologist with effect from the afternoon of the 27th October, 1948.

Mr. D. K. Chatterjee was appointed temporary Assistant Geologist with effect from the 2nd November, 1948.

Mr. C. S. Raja Rao was appointed temporary Assistant Geologist with effect from the afternoon of the 3rd November, 1948.

Mr. S. K. Ramaswamy was appointed temporary Assistant Geologist with effect from the afternoon of the 30th October, 1948.

Mr. C. K. Radha Krishna Sastry was appointed temporary Assistant Geologist with effect from the 3rd November, 1948.

Mr. B. N. Raina was appointed temporary Assistant Geologist with effect from the 30th October, 1948.

Mr. C. Gourishankar was appointed officiating Assistant Geologist with effect from the 2nd November, 1948.

Mr. A. S. L. Singha Hunday was appointed officiating Assistant Geologist with effect from the 23rd October, 1948.

Mr. N. Gopalakrishnamurthy was appointed officiating Assistant Geologist with effect from the 2nd November, 1948.

Mr. S. N. Puri was appointed officiating Assistant Geologist with effect from the afternoon of the 25th October, 1948.

Mr. T. Madhusudhana Rao was appointed officiating Assistant Geologist with effect from the afternoon of the 29th October, 1948.

Mr. Y. S. Sahasrabudhe was appointed officiating Assistant Geologist with effect from the afternoon of the 28th October, 1948.

Mr. D. Venkataramanan was appointed officiating Assistant Geologist with effect from the afternoon of the 29th October, 1948.

Mr. V. R. Venkoba Rao was appointed officiating Assistant Geologist with effect from the afternoon of the 30th October, 1948.

Dr. V. T. Athavale was appointed temporary Chemist for the Rare Minerals Section with effect from the 30th December, 1948.

Dr. S. L. Banerjee was appointed temporary Assistant Geophysicist with effect from the 15th April, 1948.

Mr. M. K. De was appointed Assistant Chemist (on probation) with effect from the 24th June, 1948.

Mr. P. D. Malhotra was appointed Assistant Chemist (on probation) with effect from the 10th July, 1948.

Re-employments.

Mr. B. C. Gupta was re-employed after retirement for six months with effect from the 16th December, 1948.

Mr. P. N. Mukerjee was re-employed after retirement for six months with effect from the 6th December, 1948.

Leave.

Dr. H. Crookshank was granted extended leave preparatory to retirement on average pay for 3 months and 9 days and on half average pay for 8 months and 21 days with effect from the 1st May, 1948.

Dr. M. S. Krishnan was granted leave on average pay for 3 months and 7 days with effect from the 16th April, 1948 to the 22nd July, 1948.

Dr. K. Jacob was granted earned leave for 15 days with effect from the 4th August, 1948.

Mr. D. R. S. Mehta was granted earned leave for 36 days with effect from the 1st September, 1948 to the 6th October, 1948 with permission to affix the Puja holidays from the 7th October to the 18th October, 1948.

Dr. F. Ermisch was granted earned leave for 18 days combined with extraordinary leave for 181 days with effect from the 14th August, 1948.

Mr. G. V. D. Upadhyaya was granted earned leave for 30 days and medical leave for 11 days with effect from the 1st March, 1948 with permission to prefix Sunday the 29th February, 1948 and to affix Sunday the 11th April, 1948.

Mr. D. Gupta was granted leave on average pay for 15 days with effect from the 29th December, 1947 and for 1 month and

29 days with effect from the 2nd August, 1948 with permission to prefix Sunday, the 1st August, 1948.

Mr. M. K. Roy Chowdhury was granted earned leave for 15 days with effect from the 1st June, 1948 with permission to affix the 16th June, 1948 being a holiday.

Mr. F. Ahmad was granted earned leave for 29 days with effect from the 25th September, 1948 with permission to affix Sunday, the 24th October, 1948.

Mr. A. K. Belgaumi was granted earned leave for 12 days with effect from the 19th October, 1948 with permission to prefix the Puja holidays from the 7th to the 18th October, 1948 and to affix Sunday, the 31st October and the holiday on the 1st November, 1948.

Mr. S. C. Chakravarty was granted earned leave for 51 days with effect from the 15th April, 1948.

Mr. V. S. Krishnaswamy was granted earned leave for 36 days with effect from the 31st May, 1948, and earned leave for 22 days combined with leave on half average pay for 15 days with effect from the 1st September, 1948.

Mr. P. Loka was granted earned leave for 11 days with effect from the 31st May, 1948.

Mr. B. N. Sinha was granted extraordinary leave for 30 months with effect from the 18th August, 1948 for overseas study as a Bihar Government scholar.

Mr. G. H. S. V. Prasada Rao was granted earned leave 11 days with effect from the 11th August, 1948 with permission to affix Sunday, the 22nd August, 1948.

Mr. Kedar Narain was granted earned leave for 23 days combined with leave on half average pay for 2 days with effect from the 15th May, 1948.

Mr. N. A. Vemban was granted earned leave for 46 days with effect from the 7th June, 1948 with permission to prefix Sunday, the 6th June, 1948.

Mr. G. Kohli was granted earned leave for 34 days and medical leave on half average pay for 30 days with effect from the 7th February, 1948.

Mr. K. S. Mahapatra was granted earned leave for 36 days with effect from the 11th December, 1948.

Mr. Y. G. K. Murthy was granted earned leave for 17 days with effect from the 7th June, 1948.

Mr. N. V. Chandrasekariah was granted earned leave for 19 days with effect from the 19th October, 1948 with permission to prefix the Puja holidays from the 7th to the 18th October, 1948.

Mr. Mohamed Ziauddin was granted earned leave for 20 days with effect from the 24th June, 1948.

Mr. M. V. A. Sastry was granted earned leave for 30 days with effect from the 19th October, 1948 with permission to prefix the Puja holidays from the 7th to the 18th October, 1948.

Mr. A. S. Ramiengar was granted earned leave for 17 days with effect from the 19th October, 1948 with permission to prefix the Puja holidays from the 7th to the 18th October, 1948.

Mr. J. Narayanamurthy was granted earned leave for 12 days with effect from the 19th October, 1948 with permission to prefix the Puja holidays from the 7th to the 18th October, 1948 and affix Sunday, the 31st October and the holiday on the 1st November, 1948.

Mr. T. Banerjee was granted earned leave for 11 days with effect from the 19th July, 1948.

Mr. M. A. Anandalwar was granted earned leave for 30 days combined with extraordinary leave for 8 days with effect from the 3rd June 1948 with permission to affix Sunday, the 11th July, 1948.

Mr. K. C. Channabasappa was granted earned leave for 5 days combined with extraordinary leave for 2 months and 27 days with effect from the 8th March, 1948.

Mr. P. C. Roy was granted leave on average pay for 2 months with effect from the 2nd November, 1948.

Mr. Manomohan Ghose was granted earned leave for 31 days with effect from the 5th November, 1948 with permission to affix Sunday, the 5th December, 1948.

Transfer.

The services of Dr. M. S. Krishnan were transferred to the Indian Bureau of Mines as its Director with effect from the 1st December, 1948.

Termination of contract.

The services of Dr. G. Dessau, Geophysicist, were terminated with effect from the 10th July, 1948 on expiry of his contract.

Retirement.

Mr. B. C. Gupta, Geologist retired from the Department on superannuation pension with effect from the 16th December, 1948. He was however re-employed for 6 months with effect from the 16th December, 1948.

Mr. P. N. Mukherjee, Geologist retired from the Department on superannuation pension with effect from the 6th December, 1948. He was, however, re-employed for 6 months with effect from the 6th December, 1948.

OBITUARY

Bankim Bihari Gupta died on the 27th October, 1947. Mr. Gupta joined the Geological Survey of India on the 21st October, 1903, and retired from service on the 31st October, 1933.

HONOURS AND AWARDS

The Government of India conferred the title of C.I.E. on Dr. W. D. West, Director, Geological Survey of India.

LECTURESHIP

Dr. A. G. Jhingran continued as part time Professor of Geology at the Presidency College, Calcutta up to 28th November, 1948, when he was replaced by Mr. A. B. Dutt.

POPULAR LECTURES

The following popular lectures were delivered by officers of the Department during the year:—

1. "Exploring for coal in Northern Afganistan" by Dr. W. D. West at the Indian Museum, Calcutta.
2. "The Mineral Wealth of India" by Dr. W. D. West at the All-India Exhibition Lecture Court at the Eden Gardens, Calcutta.
3. "Glaciation, Mountain Building and the Evolution of land plants" by Dr. K. Jacob at the Geological Institute, Presidency College, Calcutta.
4. "Mineral Springs in India" by Dr. P. K. Ghosh at the Geological Institute, Presidency College, Calcutta.
5. "Dam Sites in India" by Mr. K. K. Dutta at the Indian School of Mines and Applied Geology, Dhanbad, under the auspices of the Geological, Mining and Metallurgical Society of India, Calcutta.
6. "Our Mineral Resources" by Dr. A. G. Jhingran at the Geological Institute, Presidency College, Calcutta.
7. "Manganese Ores" by Dr. W. D. West, broadcast from Nagpur station of the All India Radio.
8. "Mineral Resources of C. P. and Berar" by Mr. A. M. Ghosh, broadcast from Nagpur station of the All India Radio.

9. " Our Minerals " in Hindi by Mr. S. M. Mathur, broadcast from Nagpur station of the All India Radio.

EXHIBITIONS

The Geological Survey of India participated in the following exhibitions during the year:—

1. All India Exhibition at the Eden Gardens, Calcutta, during February-March, 1948.
2. South-East Asia Economic Resources Exhibition at the Commercial Museum, Corporation of Calcutta, Calcutta, from the 25th September to the 3rd October, 1948, and
3. Science Exhibition at the Bangabasi College, Calcutta, on the occasion of the Diamond Jubilee Celebration of the College during the first week of December, 1948.

PUBLICATIONS

The following were published during the year under report:—

1. Records, Vol. 76, Bulletin No. 15, Notes on Tin and Wolfram in Burma and India.
2. Records, Vol. 76, Bulletin No. 16, Coal.
3. Memoirs, Vol. LXXVII, Catalogue of Publications of the Geological Survey of India and Index of Geological Maps.

LIBRARY

The additions to the library amounted to 2,495 volumes of which 623 were acquired by purchase and 1,872 by presentation and exchange.

TRAINING CAMP

The annual Field Training Camp of the Geological Survey of India was held from the 15th November, 1948 to the 4th January, 1949 in a few selected areas in the Central Provinces and Bihar. The total number of trainees participating was 33. This included 22 Assistant Geologists, one Geophysical Assistant and ten Post-Graduate students from Andhra, Mysore (2), Bombay (4), Lucknow and Patna (2) Universities.

Mr. B. C. Gupta was in charge of the camp, assisted by Messrs. K. K. Dutta, R. N. P. Arogyaswamy, P. K. Chatterjee, P. K. Ghosh and S. Narayanaswamy.

From the 17th November to the 11th December, 1948. the camp remained at Jubbulpore where instruction was given in topographical surveying involving the use of the chain, plane table, prismatic compass, dumpy level and theodolite, etc., and in geological mapping on the one inch to the mile scale. The Deputy Director (Mineral Development) visited the Jubbulpore Camp between the 7th and 11th December, 1948.

The camp was next shifted to Deolapar, on the Jubbulpore-Nagpur Road, where it remained from the 12th to the 24th December, 1948. Instruction was given in geological mapping on the one inch and four-inch scales, and in the problems of metamorphic and structural geology. I visited the party in this area and initiated the trainees in the mapping and petrological study of the formations.

Finally, the highly mineralised area around Ghatsila and Mosaboni was selected for the third camp where methods of mining and the treatment of the copper-ores were studied between the 27th December, 1948 and 3rd January, 1949. Dr. A. K. Dey joined the camp at Ghatsila and gave the trainees the advantage of his experience in the area.

The following excursions were arranged for the trainees in the course of their field training:—

1. Visit to the bauxite, limestone and clay quarries at Katni and Sleemanabad, and examination of fluorite and copper occurrences near Sleemanabad.
2. Visit to the Marble Rocks, steatite deposits and the Narbada Falls at Bheraghat.
3. Visit to the Gun Carriage Factory and Burn & Co.'s Pottery Works at Jubbulpore.
4. Visit to the Kandri and the Mansar manganese-ore mines.
5. Visit to the Indian Copper Corporation smelting works at Moubhandar.
6. Visit to the copper mines at Mosaboni.
7. Visit to the Tata Iron and Steel Works at Jamshedpur.

VIII. BIBLIOGRAPHY

The following papers dealing with Indian geology and minerals were published during the year.

AGRAWAL, S. K. . . .	The Geology & Economic considerations of the area around Kudada, Singhbhum Dist., Bihar. *Quart. Journ. Geol. Min. & Met. Soc. India*, XX, No. 1, 17-28.
AIYENGAR, N. K. N. & SUBRAMANIUM, A. P.	A note on the Petrology of the Corundum and Chromite bearing rocks of the Sithampundi-Ramadevan Area. Namakkal Taluk, Salem Dist., Madras. *Current Science*, 17, No. 7, 211.
ANON . . .	Activated Carbon from Coal. *Journ. Sci. Indl. Res.*, VII, No. 11, 501.
„ . . .	Beneficiation of Graphite from Mysore State. *Journ. Sci. Indl. Res.*, VII-B, No. 10, 167-168.
„ . . .	Benefication of Mineral Ores. *Journ. Sci. Indl. Res.*, VII, No. 9, 394.
„ . . .	Bureau of Mines. *Science and Culture*, 13, No. 11, 429-431.
„ . . .	Bureau of Mines for India. *Commerce*, LXXVI, No. 1935, 202.
„ . . .	Catalogue of publications of the Geological Survey of India and Index of Geological Maps. *Mem. Geol. Surv. Ind.*, 77.
„ . . .	Coal Conservation in India. *Commerce*, LXXVI, No. 1950, 888.
„ . . .	Critical Attitude to Scheme to Produce Petrol from Coal. *Capital*, CXXI, No. 3038, 1001.
„ . . .	Damodar Valley Project. *Commerce*, LXXVI, No. 1950, 892.
„ . . .	Developing Steel Industry in India. *Journ. Ind. Soc. Engineers*, XIII, No. 1, 7.
„ . . .	Development of Non-ferrous metals. *Commerce*, LXXVII, No. 1957, 68.

ANON . . . . Dye-stuff Industry for India.
Commerce, LXXVI, No. 1952, 983.

„ . . . . Exploiting India's Mineral Resources.
Indian and Eastern Engineer, XCXII, No. 2, 245-246.

„ . . . . Fertilisers in India.
Chem. Trade Journ., 122, No. 3183, 586.

„ . . . . Fertiliser Plant at Sindri.
New Sketch, IX, No. 7, 12.

„ . . . . Fillip to Geological Survey Activities.
Indian Information, 23, No. 242, 499.

„ . . . . Fuel Research in India.
Science & Engineering, 1, No. 4, 64-65.

„ . . . . The Future of Mica.
Capital, CXXI, No. 3038, 987.

„ . . . . Geological Survey in India.
Mining Journ., CCXXXI, No. 5905, 778.

„ . . . . Geophysical Exploration in Mysore.
Journ. Ind. Soc. Engineers, XIII, No. 1, 4-5.

„ . . . . Geophysical Prospecting for Manganese.
Science & Culture, 13, No. 10, 419.
Science & Engineering, 1, No. 3, 47.

„ . . . . Geophysical Prospecting for Oil.
Journn. Sci. & Indl. Res., VII, No. 7, 330.

„ . . . . Goverment's Policy towards Coal Industry.
Commerce, LXXVI, No. 1947, 748.

„ . . . . The Hirakud Dam.
Journ. Central Board of Irr., 5, No. 3, 215.

„ . . . . Hirakud Project.
Indian & Eastern Engineer, XCXII, No. 1, 85.
Science & Engineering, 1, No. 2, 29-30.

„ . . . . Important Mineral Finds in Mysore.
Indian & Eastern Engineer, XCXII, No. 1, 91.

ANON . . . . India.
Mining Journ., CCXXX, No. 5871, 144. No. 5879, 292.

,, ... Indian Cement Industry.
Journ. Ind. Soc. Engineers, XIII, No. 1, 7.

,, ... Indian Coal Policy.
Iron & Coal Trades Review, CLVI, No. 4186, 1157.

,, ... Indian Mineral Resources.
Metal Market Review, 1, No. 6, 11.

,, ... India's Coal Reserves.
Colliery Gurdian, 176, No. 4561, 809-811.

,, ... India's Minerals.
Capital, CXX, No. 2990, 94.

. . . India's Non-ferrous Metals Industry.
Metal Bull., No. 3255, 5.

. . Industrial Development in India.
Iron & Coal Trades Review, CLVI, No. 4183, 1019.

,, ... Iron Ore Deposits near Salem.
Indian and Eastern Engineer, XCXII, No. 2, 279.

,, ... Iron and Steel Industry for South India.
Indian & Eastern Engineer, XCXII, No. 6, 968.

,, ... Irrigation and Power Projects in India.
Indian & Eastern Engineer, XCXII, No. 1, 55.

,, ... Manufacture of Petroleum Product in India.
Science & Engineering, 1, No. 5, 84.

,, ... Measurement of Geological Time in India.
Journ. Sci. Indl. Res., VII, No. 1, 44.

,, ... Methods of Test for Soil Classification and Compaction.
Science & Engineering, 1, No. 5, 85-86.

,, ... Mica Standards.
Journ. Sci. Indl. Res., VII, No. 11, 503.

ANON . . . The Mineral Industries of India. *Tisco Review,* XVI, No. 2, 65.

" . . . Mineral Resources of Mysore. *Metal Market Review,* 1, No. 4, 9.

" . . . The Mineral Wealth of India. *Mining Journ.,* CCXXX, No. 5871, 148-150.

" . . . A New Code for Indian Coal Industry. *Capital,* CXX, No. 3005, 741.

" . . . New Indian Sulphur Deposits. *Chem. Trade Journ.,* 122, No. 3162, 24.

" . . . New Vermiculite Deposits. *Mining Journ.,* CCXXXI, No. 5905, 778.

" . . . Non-ferrous Metals Industry. *Indian Information,* 23, No. 235, 95.

" . . . Non-ferrous Metals Industry in India. *Science & Engineering,* 1, No. 3, 47.

" . . . Oil from Coal. *Capital,* CXX, No. 3005, 764.

" . . . Oil from Indian Coal. *Commerce,* LXXVII, No. 1959, 172.

" . . . Ore-dressing in India. *Journ. Ind. Soc. Engineers,* XIII, No. 1, 5.

" . . . Paint Industry in India. *Capital,* CXXI, No. 3037 (Supplementary Diamond Jubilee Number) 101.

" . . . Petrol from Coal in India. *Commerce,* LXXVI, No. 1954, 1076.

" . . . Petroleum Sources in India. *Indian Finance,* XLI, No. 6, 247.

" . . . Plans for Synthetic Petrol and Dyestuff Industry in India. *Journ. Ind. Soc. Engineers,* XIII, No. 5, 84.

" . . . Projects for Atomic Research in India. *Journ. Ind. Soc. Engineers,* XIII, No. 5, 85.

ANON . . . . Projects in the United Provinces.
Journ. Central Board of Irr., 5, No. 3, 218-219.

" . . . . Radar from Oil Prospecting.
Capital, CXX, No. 3005, 766.

" . . . . A Rare Metal in India.
Commerce, LXXVII, No. 1960, 224.

" . . . . The Salem Ore Deposits.
Metal. Bull., No. 3277, 10.

" . . . . Scientific Study of Soil Mechanics.
Indian Information, 23, No. 241, 477.

" . . . . Sindri Fertiliser Project Progress.
Journ. Ind. Soc. Engineers, XIII, No. 1, 3.

" . . . . Some Aspects of the Geology of Ceylon
Mining Journ., CCXXX, No. 5870, 133-134. No. 5872, 168.

" . . . . South India's Mineral Wealth.
Capital, CXX, No. 3008, 889.

" . . . . Standardisation of Mica.
Science & Engineering, 1, No. 5, 85.

" . . . . Synthetic Oil and Bye-Products from Coal.
New Sketch, VIII, No. 43, 10.

" . . . . Synthetic Petrol in India.
Mining Journ., CCXXX, No. 5872, 165.

" . . . . Tinplate Manufacture in India.
Journ. Ind. Soc. Engineers, XIII, No. 1, 8.

" . . . . The Use of Kankar Lime on Major Irrigation Works.
Science & Engineering, 1, No. 5, 92-95.

" . . . . Work on the Sindri Fertiliser Project.
Science & Engineering, 1, No. 4, 69-70.

" . . . . Working of the Geological Survey of India's Special Sections.
Journ. Ind. Soc. Engineers, XIII, No. 1, 4.

ATMARAM, SABOOR, M. A., KARIMULLAH, & VERMAN, L. C. .	Survey of Indian Resources of Sands and Rocks required for the Glass Industry. *Journ. Sci. Indl. Res.* VII, No. 4, 163-195.
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Dutt, A. K.	Maintenance of Soil Productivity—The key to Soil conservation in India. *Science & Culture,* 13, No. 11, 441-448.
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Ganesan, A. S.	Presence of Gallium in Micas and Schists. *Current Science,* 17, No. 3, 87-88.
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Ghosh, P. K.	Mineral Springs of India (Review of the Pres. address). *Science & Culture,* 13, No. 10, 2.
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,, ,,	Synthetic Oil from Coal—pt. II. *Journ. Sci. Indl. Res.*, VII, No. 9, 406.
,, ,,	Synthetic Oil from Coal—pt. III. *Journ. Sci. Indl. Res.*, VII, No. 10, 442-446.
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RECORDS
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NOTE ON THE DISCOVERY OF THE JHARIA COALFIELD.

BY SIR LEWIS L. FERMOR, KT., O.B.E., F.R.S.

It has long been unknown how and when the Jharia coalfield was discovered. A curious feature of the final report[1] of the Coal Committee that sat in India from 1837 to 1845 is that it contains no reference to the existence of coal in what we now term the Jharia coalfield, although coal was then known to occur in the Raniganj, North Karanpura, Hutar and Daltonganj coalfields, using the modern names. The fact that Map No. 2 accompanying the report shows the coal formation as extending to the sites of the Bokaro and Jharia fields may be of no special significance, but merely represent an intelligent surmise, especially as these two fields are not referred to in the text.

This absence of reference to the Jharia field in the above report was noted by Thomas Oldham,[2] who declined to accept that the title of a paper by 'the late Mr. Jones'[3] published in 1829, and doubtless referring to work done when Jones was engaged in working the collieries referred to in this paper, means that Jones had seen coal in Jharia, giving as his (Oldham's) reason for this disbelief that 'The map, however, which accompanies the paper does not include Jherria in the coal-field, and it is more than probable that the name was used by Mr. Jones, not as indicating the town of that name, but rather the property or "raj", which was the next adjoining to the country near the Barakur river, known to contain coal.'

---

[1] 'Report of a Committee for the investigation of the Coal and Mineral Resources of India for May 1845', 8°, Calcutta, (1846). Listed by La Touche under the name of J. McClelland, the Secretary to the Committee.

[2] *Mem. G. S. I.*, V, p. 333 (1866).

[3] Description of the North-West Coal District, stretching along the River Damuda, from the neighbourhood of Jeria or Juriagarh, to below Sanampur, in the Pergunnah of Sheargerh, forming a line of about sixty-five miles', *Asiatic Researches*, XVIII, Pt. I, pp. 163-170 (1829).

The title of the paper makes no mention of a map, and there is no indication in the bound volume of *Asiatic Researches* that the map belongs to this paper; or, if it does, that it was ever seen or prepared by Mr. Jones. The length of the coalfield shown on this map is only 40 miles and thus disagrees with the title of the paper.

It so happens that the distance of 65 miles mentioned in the title of Jones' 1829 paper is the distance in a straight line from the west end of the Jharia coalfield to the east end of the Raniganj coalfield. This must be an accidental coincidence, as the full extent of the Jharia field could not then have been known to 'the late Mr. Jones'.

But William Jones had visited Jharia. This is seen from published correspondence that has escaped even the eagle eye of La Touche, and is consequently not included in his Bibliography. It is thus that it has also, no doubt, been overlooked by Fox[1] and Gee, both of whom accept Oldham's views, and also, strangely, confuse T. Rupert Jones, who wrote palæontological papers from 1859 onwards, with 'the late Mr. Jones' (? William Jones), who was the author of the paper to which Thomas Oldham refers.

The papers overlooked by La Touche are in a volume of bound papers in the Library of the Geological Society of London.[2] On page 353 of this correspondence, in a letter dated Calcutta, 20 June 1814, from William Jones to G. Dowdeswell, Esq.. Chief Secretary to the Government of Bengal, occurs the passage:—

> 'The place where I found the coal you will trace on the 7th section of Reynel's chart beyond Ruggoonauthpoor, it is called by the natives Juhwah, but on the chart Jirwaghur'

Jones offers suggestions on how the coal might be worked. Evidently he collected some specimens of the coal, for he writes (page 354) :—

> 'The coal No. 1, was taken at Jerwah, immediately below the slate. No. 2, three feet lower, the strata is very thick; I bored six feet lower, but it still continued, and no doubt the quality of the coal improves the lower it goes. No. 3, is coal brought from England, on the Portsea, not very much superior to that near the surface at Jerwah.'

Jones' fourth specimen is of 'pipe coal found near Bancoorah'. [Coal is not known to occur at Bankura.] In view of the foregoing it seems difficult not to accept that Jones did actually sink a pit in coal at Jharia to a depth of nine feet in coal.

---

[1] *Mem. G.S.I.*, LVI, p. 2 and LXI, p. 2.

[2] First Appendix to the Third Report of the Select Committee of the House of Commons. X. Coal Mines. Appendix No. 46. Selections from Copies of Communications respecting the Coal Mines of India, received at the India House from the different Presidencies. Pp. 352-357 relate to the Damooda area; pp. 358-368 to Sylhet; and pp. 368-381 to Cutch.

In a letter dated 12th September 1915 Jones withdraws a recommendation he had made with reference to Jeriah or Jerovah, because of transport difficulties on the Damodar river, and concentrates his attention on what we now call the Raniganj coalfield. This explains why his 1829 paper does not deal with the Jharia coalfield, and why Jones' visit to Jharia in 1814 has hitherto been overlooked.[1]

---

[1] The map accompanying the paper of 1829 shows the coalfield as of smaller length than the sixty-five miles mentioned in the title (only forty miles), and as the paper is posthumous, and the map is not marked as prepared by Mr. Jones, it is difficult to accept it as evidence contradicting the statements of the 1814 letter. There is, in fact, no written evidence to show that Jones surveyed the large tract represented in this map. It is, indeed, inherently unlikely as there is no evidence that he was a geologist.

THE GEOLOGY AND MINERAL RESOURCES OF THE DATIA STATE,* CENTRAL INDIA, BY M. K. ROY CHOWDHURY, M.SC., *Geologist, Geological Survey of India.* (With Plate 2.)

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Geological map of the Datia State showing the minerals of economic importance.	

INTRODUCTION

The following report is based on the survey work carried out by the author in the Datia State, Central India. during the first half of the field-season 1947-48. Besides the mineral investigation in the State, the author carried out systematic mapping, left incomplete by W. L. Wilson in the 1870's. This re-survey was found to be more necessary after the preliminary visit to the State by H. Crookshank, State Liaison Officer, Geological Survey of India, who considered the area to be of considerable scientific interest.

As one inch to one mile topo-sheets were not available, the mapping had to be carried out on half inch to one mile topo-sheets.

---

* Since merged in Vindhya Pradesh.

The work was carried out under the guidance of Mr. A. M. N. Ghosh, Superintending Geologist-in-Charge of the Central Circle. The author's sincere thanks are due to His Highness the Maharaja and also to the Dewan who took personal interest and extended all facilities for the work. The author is also indebted to the Political Agent in Bundelkhand who showed a keen interest in the work. The author would like to mention here the good services rendered him by the State Forest Officer, Mr. Sohan Lall, who took great pains in accompanying him to the field.

PHYSICAL FEATURES

Datia State lies between Lat. 25° 30′ and 26° 17′ and Long. 78°15′ and 78°50′. The State consists of four tahsils, Seondha, Datia, Unao and Nadigaon, and is included in the Survey of India topographical sheets 54 K/N.W., K/N.E., K/S.W., J/S.E., N/S.W. and O/N.W. Of these four tahsils, the first three are adjacent to one another and form the main block, while the last one is isolated by many miles from the main section.

The physical features of the country correspond with the arrangement of the rocks. On the southern side around the city of Datia granite-gneiss forms tors and bosses in a gently undulating country. On the extreme north the semi-quartzitic rocks of the Gwalior series form a fairly broad plateau-range with a steep scarp to the south, overlooking the thickly covered central region of the State. In the central alluvial plains occasional long narrow ridges composed of quartz-reefs form a most striking feature of the landscape. Out of the plains rise many gneissic hills, isolated or in groups Thus there is no sharp line between the alluvial plains and the gneissic country.

Boundary.

The territory is much cut by the intervening parts of the Gwalior and the other States, the main section being bordered on the north and west by the Gwalior State; on the south partly by the Gwalior State and partly by the Jhansi district, U. P.; and on the east by the Samthar State and the Jhansi district.

The State has an area of 911 sq. miles with a population of about 2 lacs and revenue of about 20 lacs.

Drainage.

The Sind and the Phauj are the only important streams in the State. The former runs along the western boundary and crosses the Seondha tahsil, south of the quartzite plateau, and ultimately takes a northward course along the north-east boundary of the

State. The Phauj with its main tributary, the Angori flows for some distance along the south-eastern boundary of the State near Unao. The main affluents of this stream, namely, the Harwaya *nala* and the Parron *nala,* are within the State.

The narrow gaps by which the minor streams in many places cross the reefs give peculiar facilities for the formation of lakes, as a very short dam is often sufficient to pond back a large surface of water.

Flora and Fauna.

The trees met with in the jungles are of no great value, being mostly of the mimosa family. Though the forests are reserved, no regular attempt has been made to work them commercially. Proper planning and development will increase the revenue to a great extent. As a result of game preservation by His Highness the Maharaja, the forests of the State abound in wild animals of various kinds. Tigers, leopards, sambar, chital, antelope, and *nilgai* are met with. Ordinary small games are plentiful. The peacock, which is considered as a sacred bird has multiplied to a menacing number. Not being satisfied with the destruction of the crops they enter into the kitchens to take share of the cooked food.

The area is subjected to extremes of both heat and cold. The annual rainfall averages 38 inches. In general, the climate is bracing.

Communication.

The chief means of communication are the cart-tracks. Gwalior-Jhansi high road (52 miles), the feeder roads to Seondha (40 miles) and Unao (10 miles) are the only metalled roads. The main line of the Great Indian Peninsular Railway traverses the State near its southern boundary with stations at Datia, Sonagir, and Kotra. Some of the cart tracks are motorable in fair weather.

PREVIOUS WORKERS

The geology of Bundelkhand was first written by H. B. Medlicott (*Mem. G. S. I.*, Vol. II, pp. 1-95, 1860) which is still found to be fairly exhaustive and complete by itself. Between the years 1860-69 extensive surveys were made in the various portions of the Vindhyan area including Bundelkhand. F. R. Mallet incorporated the results of these surveys in his monograph on the Vindhyan system of the North-Western and Central Provinces of India (*Mem. G. S. I.*, Vol. VII, pp. 1-26, 1871). W. L. Wilson prepared detailed geological maps of the whole of

Bundelkhand on the scale of one inch to the mile. But unfortunately, Wilson left no report of his work. C. A. Hacket, however, published detailed accounts of the geology of Gwalior and its vicinity in 1870 (*Rec. G. S. I.*, Vol. III, pp. 33-42 and *Rec. G. S. I.*, Vol. X, p. 84). In 1906 E. W. Vredenburg published notes on the geology of this region (*Rec. G. S. I.*, Vol. XXXIII, pp. 254-260 and 261-273), but these mainly deal with the Vindhyans. D. N. Wadia, while in the Geological Survey of India, visited the lead deposit in the Seondha tahsil of the State (*Rec. G. S. I.*, Vol. LIV, p. 341, 1922). H. Crookshank carried out a preliminary investigation of the minerals and water-supply of the State prior to the author's visit there. The author has taken the liberty to incorporate in this paper the apt descriptions given by some of the previous workers.

GENERAL GEOLOGY

The following are the classified rock groups of the area :—

Recent			Alluvium, Kankar
		Erosion unconformity	
Purana	Gwalior series	Morar stage	Jasper and Iron-shales
		Par stage	Quartzite Sandstone
		Erosion unconformity	
Archaean			Dolerite Quartz and pegmatite veins Granite-gneiss

ARCHAEAN

Granite-Gneiss

The granite-gneiss is by far the commonest rock of the area. It forms the basement and is a part of the Bundelkhand gneiss which forms 'a great bay surrounded by cliffs of the overlying Vindhyans'.

The rock is a medium to coarse-grained massive granite. Foliation is seldom well-developed. Near the southern boundary of the State, however, the granite grades to highly gneissic varieties. The foliation generally has an E.N.E. direction but locally varies to N.E. and E.S.E. The planes of foliation are more or less vertical. The gneiss is in the habit of weathering concentrically with large spheroidal masses. There are two major systems of joints in the granite, striking between N.W.-S.E. and N.N.W.-S.S.E., and between N.E.-S.W. and E.N.E.-W.S.W. respectively.

With regard to texture, every variety is met with from a homogeneous fine-grained rock in which no individual mineral can be distinguished, even with a lens, to a coarsely porphyritic rock showing felspar crystals more than two inches long.

The granite-gneiss consists of quartz, felspars (mainly orthoclase), biotite and hornblende. Pink felspar is more common in the porphyritic granite that crops out in the Sind river. The bulk of the granite exposed on the southern tract of the State hardly shows pink appearance. The predominant felspar in the rock is microcline. The plagioclase felspar is a comparatively uncommon mineral; when present, it occurs in much smaller crystals than the orthoclase. As often as not, no quartz can be detected in the gneiss. Biotite and chlorite are the predominant ferro-magnesian minerals in the rock. Hornblende usually occurs as a minor constituent of the granite; and it seems to be the only mafic constituent in some of the darker bands in the gneiss.

Of the various forms of schists which are to be observed in the Bundelkhand gneiss in the present area, some dark schistose bands deserve special notice. Schistose hornblendic rocks in the gneiss are very common in the southern part of the area, particularly around Agora, Nichrauli, Ikahra, Dharwari, etc. The peculiarity of distribution and mineral assemblage of the rocks suggests that they are probably hybrid variants of the hornblende-schist inclusions. A specimen of fine-grained rock from Nichrauli under the microscope, shows rather an even mosaic of quartz and felspar. Hornblende and biotite being arranged in a linear fashion give a schistose appearance to the rock. Biotite seems to have formed after hornblende. Hornblende shows cores of pyroxene (uralite). The accessories are apatite, sphene and magnetite. A specimen of similar rock from Bijora consists of quartz. felspars (orthoclase, microcline and plagioclase), hornblende, chlorite, diopsidic pyroxene, sphene and iron oxide. Orthoclase, the predominant felspar, usually alters to sericite. A specimen of dark fine-grained variation in the porphyritic granite-gneiss near Agora shows both hornblende and biotite. In the coarser grained varieties of this rock, so commonly observed in the massive granite north of Unao, biotite is the only ferro-magnesian mineral. In these rocks sphene is an important accessory.

Bands of fine-grained quartzose gneisses are also to be observed in the granite. A specimen of this rock from Bahadurpur consists of quartz, felspars (orthoclase, microcline and plagioclase), biotite and chlorite. The rock is much granulated with wavy extinction of the constituent minerals. Garnet is an important constituent of the rock.

Quartz-reefs

The area covered by the Bundelkhand gneiss has been cut by many quartz-reefs. They are fairly equally distributed over the ground. The reefs with serrated summits add much to the scenic grandeur of the area. The majority of the quartz-reefs strike between 20° and 80° east of north, their main direction being N 35° E. In some minor cases, e.g., near Bhawanipur and Rera, quartz-reefs with north-south alignment are noticed. Near Laraita, Parsara and Bikar the quartz-reefs strike N.N.W.-S.S.E. Instances of bifurcation of the reefs and change of their strike are occasionally seen. The width of the veins vary from a few feet up to 200 feet or more. Some of these are traceable in a direct line for a few miles; sometimes these are discontinuous, which may be due to the removal by denudation of the intervening portions, or due to 'strangulation' of the vein itself. Other reefs, again, though of full thickness and very prominent at the surface, are short, and end abruptly.

The reefs are very often affected by joints. When the joint direction runs parallel with the strike of the reef itself, the joint plane gives the impression of a bedding plane. The quartz is often much shattered. Many of the quartz-reefs, as well as the gneiss itself are traversed by younger and thinner veins of quartz.

The quartz-reefs are almost entirely made of quartz but at places, a little of interstitial greenish material, probably serpentine, has been marked, e.g.. near Shiam Pahari. Quartz-reefs containing galena, chalcopyrite, etc., occur near Chitai and Bara Ratangarh (Lokendrapur).

Besides the quartz-reefs, some pegmatites are at many places found to have traversed the Bundelkhand gneiss with which they are genetically related. The pegmatites consist chiefly of quartz and microcline felspar. The pegmatite veins near Chitai contain small books of mica which are of no economic value.

Dolerite dykes

The gneiss is also remarkable for being traversed by extensive trap intrusions, none of which penetrate the younger formations. These dykes are more numerous than the quartz-reefs, and exhibit nearly as much regularity in their alignment, their prevailing direction being about N. 35° W., so as to cut the reefs obliquely at an angle of about 70°. Many of the dykes are of considerable size, a breadth of 100 feet being quite frequently met with. They often persist for great distances.

The dykes and the quartz-reefs are rarely found to intersect one another. In most cases the dykes run close up to the reefs on both sides without cutting them, e.g., west of the road-crossing near Gulab Bagh in Datia city and near the village of Taga. Near Nargarh the basic dyke which fails to cut the quartz-reef south of the village, seems to have penetrated completely into another reef north of the *nala*. At the latter place the trace of the basic rock is observed almost near the top of the quartz vein.

The commonest type of the dyke rock is an extremely hard and tough close-grained dolerite. The rock usually weathers into large rounded blocks with a tendency to exfoliate. Some of the small dykes are of earthy texture. The dykes south of Pagara and near Nargarh contain disseminated specks of chalcopyrite. The Nargarh dyke which continues almost up to the hillock of Chandeva, shows dissemination of this mineral all along its length, but nowhere it is sufficiently concentrated to be of any economic use.

Under the microscope, the rocks show ophitic penetration of the felspar laths in the ferro-magnesian minerals, mostly augite. Uralite and chlorite are the common constituents of the rocks. In some of the coarse-grained varieties of the rock, e.g., near Agora, the pyroxene is mostly altered to hornblende. Usually iron oxide is quite plentiful. A specimen from the extremely fine-grained basic rock from Pagara, under the microscope, shows laths of plagioclase and augite, embedded in a groundmass of vitrified glass. Augite is occasionally chloritised.

GWALIOR SERIES

The exposures of the Gwalior series form the plateau-range north of the Sind river in the Seondha tahsil. This plateau is the easternmost continuation of the fifty-mile long ridge that stretches east-west from the city of Gwalior. The relation of these rocks to the Bijawars, to which they bear some general resemblance, is as yet unsettled. Both occupy a position between the gneiss and the Vindhyans in geological succession, but geographically they are widely separated.

The composition of the Gwalior series is very mixed, and admits of only a two-fold and very unequal sub-division, *viz.*, the Par stage and the Morar stage.

Par stage

This lower member of the series has been named after the village Par, 15 miles south-east of Gwalior where the rocks are typically exposed. The stage consists principally of sandstone, quartzite and some thin bands of shale. No definite subdivision is possible because none of the beds are sufficiently strongly marked or continuous along the strike to be used for the purpose.

Sandstone.

At the base of the quartzite which constitutes the bulk of the group, there are occasional thin exposures of ferruginous sandstone. The exposures are best observed at the base of the quartzite in the Sind river section near Seondha and also below the quartzite beds near Chitai. At the latter locality the demarcation between the sandstone and quartzite is not very marked and at places one merges into the other. The nature of the junction of sandstone with quartzite is well-exhibited in the places where the ridge is much serrated by bays and headlands. The mechanical texture of the sandstone is unaffected at the bottom contact layers. The sandstone was deposited upon a very irregular denuded surface of the gneiss. A few inches of the base of sandstone is conglomeratic, being formed of rolled pebbles about the size of a pea enclosed in a gritty red matrix. The sandstone is ferruginous with irregular red tints. Sometimes it resembles red sandstone of the Vindhyan age.

The thickness of the sandstone varies considerably. In some places, there are only a few feet of it between the gneiss and the quartzite, but the 150 feet hillock south of Chitai is entirely made of sandstone. The sandstone bed is not uniform in thickness and thins out very frequently. Instances of false bedding are quite common. Ripple marks are also observed on the exposed surfaces.

The sandstone near the Jaswant Bridge at Seondha shows thin intercalations of shale. The shaly layers are mostly confined near the base. The hematitic shales are thinly laminated, often papery.

Quartzite.

The quartzite which is by far the abundant rock of the series forms the main plateau with steep scarps to the south. On the northern side the rock gently slopes down along the dip and is concealed under thick alluvium or occasional beds of the Morar stage.

The quartzite is a compact and massive rock and breaks with conchoidal fracture. The colour varies from pale grey to various shades of pink. Usually the rock shows uniform fine-grained texture with semi-vitreous lustre. But occasionally, as on the ridge south-east of Tuki, thin intercalations of gritty sandstone are not uncommon. A specimen of hard quartzite from the hillock, west of Dongarpur, under the microscope, shows an interlocking mosaic of quartz and a few felspars—mostly microcline. The binding material is chloritic.

Generally the rock is regularly and thinly bedded with close sets of joints, the prevailing directions being N.N.E. and W.N.W. On the eastern side of the ridge, minor local foldings are present in an otherwise horizontally bedded quartzite.

The quartzite is intruded by numerous veins of quartz. They are particularly abundant near Bara Ratangarh (Lokendrapur). The veins vary in size from the fraction of an inch to a few feet across. Crystals of quartz of varying shades and sizes are found in the cavities and vein fillings of the thicker quartz-reefs. Near Uchar there are two outcrops of red ferruginous quartzite which stand out from the alluvium like massive walls. The rock is compact and too hard to break with a hammer. It is well-jointed, the vertical joints giving the impression of bedding planes. The stratigraphical relation of these detached blocks of quartzite with the Par rock is uncertain.

On the top of the Par quartzite there occurs locally a compact calc-siliceous rock with peculiar weathering. The honeycombed quartzose rock which is occasionally observed at the base of the Morar group is perhaps the more siliceous band of this rock. The more calcareous portion of this rock reacts with HCl. A section of a specimen from the outcrop, east of the ruined fortress of Bara Ratangarh (Lokendrapur), under the microscope, shows crystalline silica of pisolitic texture. Calcite, often with crystalline outline, is quite common. Iron oxide may be present. In the more siliceous types calcite is absent.

Morar stage

The rocks of this group exposed in this area consist of argillaceous shale, finely laminated ferruginous shale with siliceous concretions, hornstone beds, black carbonaceous shale and white clay.

The maximum thickness of the group is seen near Lokendrapur where it exceeds 200 feet. Though the beds of this group are more or less horizontally disposed, foldings are quite common. The exposures as a whole show a slight roll. The hillock made of ferruginous shale of this group, south of Lokendrapur, forms an anticline pitching towards east.

In the present area the Morar stage is represented mostly by thin flaggy siliceous or ferruginous shales copiously interbedded with hornstone and chert, both finely banded and concretionary. The finely laminated ribboned shales show siliceous concretions occurring as flattish balls, usually 1½ inches along the shorter, and 2½ inches along the longer diameter. The longer diameter of the flinty chert always shows parallelism to the bedding. Some of the cherty bands are 3 to 4 feet long and 3 to 4 inches thick; their corners are always drawn to a hyperbolic shape. At Diroli bands of hornstone are quite common in the ferruginous shale. The rock is found near the bottom of the group. At Gayara and Diroli white clay underlies the concretionary ferruginous shale.

In the debris from the wells near Diroli pieces of black carbonaceous shale were picked up. The shale is occasionally slightly micaceous and finely laminated. The shale contains only a trace of carbonaceous matter and hence is of no economic use

ECONOMIC ENQUIRIES

Galena

The deposit of galena in the Seondha tahsil mentioned by Medlicott (*Rec. G. S. I.*, Vol. VIII, p. 58) and Ball (*Geology of India,* Vol. III, p. 299) was investigated by Wadia (*Rec. G. S. I.*, Vol. LIV, p. 341). In accordance with Crookshank's recommendation, the present writer took up a thorough prospecting by opening up the vein either by removing the alluvial capping or by digging shallow trenches.

The quartz-galena lode occupies a fracture caused by a sharp monoclinal folding of the rocks. The rocks are quartzite and ferruginous sandstone with intercalations of ferruginous shales of the Gwalior series. In this thickly covered country, rocks are only sporadically exposed in the river bed. The thickness of the alluvium forming the river bank occasionally exceeds 50 feet or more.

The vein varies from 1″ to 6″ in width. It runs N.E.-S.W. and heads steeply to the S.E. The richest outcrop is seen in the feeder *nala* to the south where nests and irregular masses of galena are dispersed in the white quartz. Further south, beyond the thick cover of alluvium, fault fissure is observed in the ferruginous sandstone which is exposed in the *nala* section, but no trace of quartz vein or 'superimposed' mineralisation could be seen. It is unlikely to get any good concentration of ore below the alluvium that covers the rocks between the feeder *nala* and the main river to the north, because as soon as the vein leaves the alluvium it is rapidly impoverished by repeated branching out into thin stringers of quartz vein carrying occasional insignificant quantity of galena. If further prospecting by cutting deeper trenches along the barren fissure, south of the feeder *nala,* fails to strike the lode then the prospect of the area will be greatly diminished and will depend only on the richness at depth of the quartz-galena vein, exposed in a limited area.

Besides galena, tiny patches of malachite and a few grains of pyrite are discernible in the ore.

A polished section of the ore, under the ore microscope shows that galena has been partially replaced by covellite. Chalcocite has probably come later than covellite and it carries the silver content of the ore.

Cupellation tests of the samples collected by Wadia yielded (as a mean of 3 determinations) 4·76 ozs. of silver to the ton of ore. The following results were obtained from the groove samples collected by the present writer from the spots where comparatively richer concentrations were noticed :—

	Ag. (ounces per long ton)	Radio-active test.
a.	2·77	Nil.
b.	0·56	"
c.	0·46	"
d.	0·98	"

Considering the state of mineralisation and the length and width of the vein, the author is of the opinion that the deposit is of no great economic value. However trenches should be made along the fault-fissure, exposed in the feeder *nala.* Further encouragement for prospecting will depend on the presence and the nature of mineralisation of the vein there.

Associated with the crystalline quartz which occurs in the cavities and vein fillings in the quartz-reefs east and south-east of Lokendrapur and Chitai respectively, there are small crystals of galena, cuprite and bornite. Green stains of malachite are also common. The minerals in these occurrences are confined to thin zones near the cavities and are too sparsely disseminated to be of any commercial use.

Red ochre

Bands of red ochre are observed at many places in the concretionary shales of the Morar stage between Gumanpura to the east and Lokendrapur to the west. The beds of ochre are the results of the various stages of hydration of the highly ferruginous portions of the Morar shale.

The bands of ochre in the finely laminated ribboned shales east of Gumanpura are very thin and cannot be explored economically. The constant presence of siliceous concretions is also a great defect. The ochre bands do not improve even when the concretions are decomposed because such decomposition usually leaves gritty patches. Purer and thicker bands of hematitic shale passing to soft red ochre occur on the eastern flank of the hillock ·632, south of Diroli.

The best development of red ochre is observed on the ridge south of Lokendrapur where a few thin beds of soft and fine-grained material occur in the concretionary hematite shale. The shale beds here form an anticline pitching to the east. The underlying rocks, however, show almost a flat dip. On the eastern flank of the ridge grey or white clay is exposed.

The area is under the lease of Messrs. Prakash Industries who are mining a 3½-foot bed of red ochre on the western flank of the ridge. The underground work is carried out by means of pillar and stall method. There are three shafts through which the bed is approached and the material is carried to the surface on head. The place is connected with the nearest rail-head at Morar, a distance of 36 miles, by a fair weather cart-road. According to Messrs. Prakash Industries the material is not suitable for the manufacture of paints and its only demand is for colour wash. In most cases the trade prefers big lumps to the ground material. The monthly output is 2,000 mds., working 8 months in the year. The royalty is 3 annas per ton, out of which 1 anna goes to the Gwalior State for transporting the material through its territory. The average total cost up to the rail-head is about Rs. 60 per ton.

The quantity of Fe_2O_3 in the samples of ochre collected from Diroli and Lokendrapur is 21·76 per cent. and 23 76 per cent. respectively. The iron oxide content of the above ochres is likely to stand the dilution required for paint and pigment service. They can at least be utilised as base material for red paints. To increase the chroma other red pigments may be added.

In the opinion of the author the mining of the material is being done satisfactorily. As it is desirable that the State should know the extent of the deposit, a systematic exploration is necessary. Due to contortion of the strata the trial pits may not always lead to satisfactory results. The risk will, however, be much minimised if the structure of the area and the high dips of the shales are kept in mind. Apart from the trial pits, open trenches and adits may be necessary wherever the structural features demand it. Occasional exposures of ochre all over the ridge and old pits near the State boundary line warrant that a thorough prospecting should be undertaken in the near future. The project for linking Seondha to Datia with a 2-foot gauge light railway will largely depend on the development of this area. To improve the output, and particularly to relieve the manual labour to be employed for the exploration work, the company should put up simple mechanical haulage.

White clay

Exposures of white clay are observed in the banded jaspery or concretionary shale near Gumanpura, Gayara, Lokendrapur and Diroli.

Gumanpura.

The occurrences of clay in the Sind river section near Gumanpura are of the nature of thin irregular bands in the decomposed shale. The clay is gritty and mixed up with yellow ochreous shale. It can only be used locally for white-wash.

Gayara.

Bands of pinkish white clay occur at a depth of about 30 feet in a dried up well in the Gayara Fort. The bands are thin and impure and most probably have been derived from the decomposition of the hornstone or siliceous bands in the shale. The clay has fair plasticity but vitrifies below 1350° C. The linear shrinkage is negligible and the colour of the brick after burning is dark brown. This rather dense burnt clay may be used for terra cotta, stone ware, sanitary ware, etc.

Lokendrapur.

Though greyish white clay is frequently exposed in the shales near Lokendrapur, exposures of good white clay could hardly be seen. A few small trial pits in the slopes of the ridge occupied by clay will give a good idea as to the existence and quantity available of pure white material.

Diroli.

White clay of workable size is exposed on the upper slopes of the hillock east of Diroli. The clay is inter-stratified with ferruginous shale and shows a slight dip to the north. The extent of the clay bed along its dip is not known. Adits up to 50 feet or more have been driven by the local people in this deposit.

The white clay is not persistent and rather impure, being inseparably mixed up with earthy or yellowish clay material. In some of the pits, the clay is of variegated type with alternate bands of yellowish and pinkish materials. Separation of the white material is a tedious process.

Physical tests of the three average samples of clay collected from Diroli gave the following results :—

	1	2	3
Plasticity	Fair	Fair	Fair.
Fusibility at 1300°C	Begins to vitrify	Begins to vitrify	Begins to vitrify
Fusibility at 1350°C	Vitrifies completely	Vitrifies completely	Vitrifies completely
Shrinkage (linear)	2. 5%	5%	Negligible
Colour after firing at 1350°C	Buff	Dark brown	Dark brown

The clays are open burning and of fairly high strength. These may be used for terra cotta, stoneware, sanitary ware paving brick, etc.

A trench about 5 feet wide and 15 feet deep will give a fair idea as to the thickness and width of the clay deposit. It will also be advisable to drive a few small adits at the same altitude on the east and west flanks of the hillock.

Iron ore

Slag heaps, suggesting ancient smelting of iron ore are found at many places, particularly near Gyara and Lokendrapur. The ancient smelters were most probably using the thicker bands of hematite in the variegated shale as their ore. The iron ore which was largely mined from the Gwalior formation is quite different from that found in the Bijawars. The latter is a massive concretionary hematite, irregularly concentrated in ferruginous earthy sandstone. The Gwalior ore is a fine wafer-like shale composed of thin flakes of hematite with still thinner films of clay. It is a decomposed condition of the jaspideous shale. The amorphous silica has been dissolved, leaving the iron ingredient in a favourable state for mining and smelting in the local indigenous furnaces. This change has occurred near the base of the formation and most of the quarries are in the shales a few feet above the Par sandstone. The small segregations of iron ore in the shales can only be tapped for the local indigenous furnaces.

Black shale

In the debris excavated from the wells west of the village of Diroli and also in the valley west of Baghatoli, black carbonaceous shale was noticed. The exact depth at which this shale occurs is not known due to the antiquity of the wells. But as the excavated material from a 32 feet well near Baghatoli shows the carbonaceous shale which is missing in the debris from the shallower wells in the neighbourhood, it is evident that the shale bed occurs near the bottom of the well. Judging from the percentage of carbonaceous material in the debris, it is presumed that the carbonaceous shale occurs as thin laminae in the clayey shale. The extent of the shale bed is limited because only the wells in a N.E.-S.W. zone, between Baghatoli and Diroli, show debris of this rock. The shale contains only a trace of carbonaceous matter. The commercial possibility of utilising this shale in the paint industry should be explored. This shale after necessary grinding may be tried for foundry facings.

Amethyst

In the cavities and vein fillings of some of the quartz-reefs, e.g., south-east of Chitai, near the old fort at Datia city, around

Gangari and in the hillocks of Chandeva, amethystine quartz is observed. In none of these occurrences a good crystal of happy colour and suitable size was noticed. In the quartzite ridge north of the Sind river there are some thin veinlets of quartz containing crystals of black and red quartz. The crystals are opaque and probably of no use to the jewellers.

The author fully agrees with the following views of Crookshank regarding the economics of amethyst in the State :—

> 'Nearly all the amethystine quartz seen by me was pale in colour, brittle, and cross-grained. I very much doubt whether it would be any use to a jeweller. I saw one very beautiful necklace in the collection of the Maharaja of Datia consisting of very fine amethysts of beautiful colour with beads of bright green emerald between the main stones. These amethysts were formerly found in Datia and were cut and mounted in Delhi. I think it likely that similar amethysts still exist in this quartz ridge but probably only one in a million would be worth cutting. From the point of view of the State, I think it doubtful whether it would be worth while giving any one a mining lease for such an irregular and uncertain mineral. The probability is that the lessee would get nothing worth while. If he was lucky and found some good stones he could probably get all that could be profitably sold in a year in a couple of months so that there would not be much local labour employed. I think it would be worth while giving a prospecting license for the area to any lessee prepared to cut the amethysts in Datia and train up the local labour in this art.'

Building stones

The granites, quartzites and sandstones occurring within the State can be utilised as building stones. Besides, the basic dykes and the quartz-reefs can also be used as road metal and building stones of less importance.

Sandstone.

The ferruginous sandstone of the Par stage may conveniently be used for the purpose of building and engineering projects of the State. Frequent cross-bedding, however, is a great defect in quarrying out large slabs of sandstone. Thin flaggy sandstone exposed near the Jaswant Bridge of Seondha, and similar rock cropping out at the sharp bends of the Sind river near Kitana, are strong enough to be used as roofing or flooring tiles. Moreover, the occurrences are favourably situated in respect to transport facilities.

Shale.

The concretionary shale is being extensively used for house-walls, well-linings, etc. Due to well-developed vertical joints the shale can easily be quarried. The loose and friable nature of the rock, however, does not render it suitable for use in heavy masonry work.

Quartzite.

Close joints, irregular fracture and extreme hardness of the massive bedded quartzite, north of the Sind river, render it unsuitable as building stones. The rock may, however, be utilised as rubble stones, stone chips and road metal. The quartzite that stands out from the alluvium like two gigantic walls near Uchar is similar to the quartzite that is being quarried for grinding stone in the neighbouring areas in the Gwalior State. As the rock is well-jointed and has the requisite strength, the State should train up the local people in the art of quarrying and grinding this rock.

Granite.

Massive as well as gneissic granites yield building stones of superior quality. Their popularity is due to their great crushing strength, durability, variety of colour and susceptibility to high polish. They are widely used in the construction of large and heavy buildings, dams, bridge-piers, etc. As the State is mostly formed of granite-gneiss of various shades and texture extensive quarrying and dressing of the rocks may be easily undertaken. Due to the presence of horizontal and vertical joints at many places, quarrying will be quite easy. For the new projects of roads for heavy traffic, granite may be used as soling. The crushed rock may be employed as aggregate in the concrete or in the tar-bound roads.

Reef-quartz.

The numerous quartz-reefs are the inexhaustible source of road metal in the State. The road side occurrences are worked from time to time. Some of the veins near Datia railway station are being quarried for ballast. As this rock is crushed easily under heavy traffic forming thick dust it should preferably be used in building tar-bound roads. This rock in dressed condition may be used as road kerb and paving stone, and the large angular blocks as pitching stones.

Dolerite.

The dolerite dykes will yield much better type of road metal because it will stand well under heavy traffic conditions both in ordinary and tar-bound road. This rock will serve the purpose of pitching stone very well. The material may preferably be used as stone-chips in building reinforced concrete structure. The proximity of the dykes to the principal all-weather roads is a great advantage in utilising the rock for constructional purposes.

Kankar.

The *nalas* draining the badland country in the State are occasionally thickly covered with *kankar* (calcareous concretions). At present the material is being used for lime burning locally. Individually none of the occurrences is worth developing even on a modest scale, but a combined collection from all the deposits will meet the demands of the State. After burning, *kankar* yields hydraulic lime (a lime which has better binding and cementing properties) used so much in building strong foundations for large masonry structures. This material had been in use as a successful source of lime from time immemorial.

WATER SUPPLY

Water is always a great problem in this semi-arid country of Central India. The water table which is between 50 to 60 feet from the surface in winter, goes down considerably during the summer months. During that period even the main channel, the Sind river, goes almost dry. As the mineral resources of the State are limited, attention should be diverted to improve it agriculturally. A judicious application of the suggestions put forward by Crookshank in his report (see Appendix) will be helpful in removing the hardship of the city dwellers and will improve the State agriculturally. In the opinion of the author more detailed information should be collected before a scheme is undertaken. The most important information would be the actual amount of water carried by the channels and the respective levels of the sub-surface water-table during the seasons of the year.

For a general examination of the sub-soil hydrology the area of the State may be divided into (1) the northern sandstone and shale tract, (2) the central alluvial tract, and (3) the southern granitic tract. In the northern tract, the favourable artesian conditions may be found out by careful examination of the rock associations and their structures. Sinking of tube wells may be feasible in the central alluvial tract, if the thickness is found favourable for the purpose. As the granitic rocks do not favour circulation of ground water, advantage should be taken or in constructing small dams in the frequent gaps in the quartz reefs and the basic dykes, topographical and geological conditions permitting, to pond back reserves of water.

LOCALITY INDEX

Agora	(25° 36′:78° 27′)
Baghatoli	(26° 12′:78° 43′)
Bahadurpur	(25° 42′:78° 33′)
Bara Ratangarh (Lokendrapur)	(26° 10′:78° 39′)
Bhawanipur	(25° 42′:78° 31′)
Bijora	(26° 14′:78° 47′)
Bikar	(25° 42′:78° 33′)
Chandeva	(25° 42′:78° 32′)
Chitai	(26° 7′:78° 39′)
Datia	(25° 42′:78° 27′)
Dharwari	(25° 40′:78° 35′)
Diroli	(26° 12′:78° 42′)
Dongarpur	(26° 6′:78° 39′)
Gangari	(25° 36′:78° 28′)
Gayara	(26° 13′:78° 44′)
Gumanpura	(26° 13′:78° 47′)
Ikahra	(25° 40′:78° 33′)
Kitana	(26° 9′:78° 45′)
Laraita	(25° 37′:78° 30′)
Nargarh	(25° 35′:78° 37′)
Nichrauli	(25° 38′:78° 24′)
Pagara	(25° 35′:78° 30′)
Parsari	(25° 36′:78° 35′)
Rera	(25° 43′:78° 30′)
Seondha	(26° 9′:78° 47′)
Shiam Pahari	(25° 57′:78° 33′)
Taga	(25° 35′:78° 32′)
Tuki	(26° 12′:78° 46′)
Uchar	(25° 53′:78° 27′)
Unao	(25° 35′:78° 36′)

APPENDIX

(*Extract from H. Crookshank's unpublished report, submitted on 11th October, 1947*)

Water Supply

I was asked for an opinion on the proposed schemes for the water supply of Datia town.

They are in a somewhat nebulous state. The various proposals are :—

Water Supply for Datia Town.

1. To pump water from the Sind R. 12 miles distant. To filter the water at the old fort and deliver it by pipe to the town.

2. To bring the water from a new reservoir to be constructed 3 miles S.W. of Datia.

3. To pump the water from the Ram Sagar Tank about 3 miles west of Datia.

4. To pump water from wells in the vicinity of Datia.

Scheme 1.—I consider it quite unnecessary to go 12 miles from Datia for water which could be obtained much nearer the town.

Scheme 2.—I think the watershed available at the proposed site for the new reservoir too small. The reservoir would also be very shallow and would suffer very severe losses from evaporation. I feel confident that this scheme would be useless in dry years when the need for water supply would be greatest.

Scheme 3.—The Ram Sagar tank is ancient. The principal dam blocks a narrow valley which drains some 18 sq. miles of hilly grass land and forest. This dam is about 40 feet high and between two and three hundred yards long. There are two low dams blocking side valleys through which the overflow from the main valley is now diverted.

The water impounded covers an area guessed at ½ sq. mile and has a maximum depth of about 30 feet. At present most of the water in this dam dries up in the hot weather. This is partly due to serious leakage in the main dam, partly to evaporation which probably accounts for the loss of 2/5ths of the water stored and partly to use of the water for irrigating village lands below the dam.

The dam is earthen with an ancient facing of masonry. So far as is known it is made of rather porous sandy soil, and there is no puddle core to stop leakage. The ancient masonry facing rise some 15 feet above the level of the water when the tank is full, and appears to have been designed for a tank much deeper than the present one.

The shallowness of the tank at present is ensured by a gap in one of the side *bunds* which allows the surplus water to escape. I looked at this overflow and guessed it at about 100 cusecs. This continues for about 3 months in each year. This large overflow would, if dammed back, easily fill the tank another 10 to 15 feet, as seems to have been the original intentions of the tank's builder. This would double the effective storage of the tank.

A number of engineers between 1920 and 1930 have recommended that the leaks in the main *bund* be stopped, and that it be built up to its full height. Some work was even begun on this project. A modern spillway was built which now stands some 12 ft. above high tank level and the *bund* was raised at one end to a level several feet above the spillway. For some reason which is not clear but may have been connected with the slump of the early thirties the work was never completed. The tank and irrigation ditch leading from it appear to have been neglected for many years now, and there are many serious leaks which imperil its stability.

In my opinion work on this tank should be commenced again as soon as the water is low enough to permit it. The first thing to do is to stop the leakage. I feel sure that a well-rammed puddle trench properly bonded into the rocky floor and sides of the dam would reduce the leakage to insignificant proportions. Suitable soil for such a puddle trench would probably be found in large amounts in the bed of the old tank.

As soon as the leakage has been effectively calked, the main dam should be taken up to its full height, the side dams raised where necessary, and the irrigation ditch repaired and lengthened. I feel sure this dam is capable of irrigating double the area now irrigated, and would probably provide Datia with excellent water free from all contamination as well if a 3-mile pipe line from the tank to the town were laid and the necessary arrangements for pumping it were installed. The demand for pumping purposes does not seem excessive.

The dam-site is an excellent one between granite hills. The catchment is large and consists of hilly granite country almost entirely grazing land or jungle where no serious contamination would be possible. Increasing the size of the tank would not destroy any valuable tillage or forest land. The cost of the work could easily be estimated by the State Engineer, but in my opinion would be small compared with the cost of constructing a new tank.

I do not think it desirable to spend money on an expensive pipe line and pumps to give a piped water supply to the town of Datia from Ram Sagar until the tank has been repaired and its level raised. It would be prudent to allow a year or two to pass after this work is complete to see whether after using the water for irrigation there remains adequate for the town water supply. This would mean a delay of 5 years during which time the price of pipes and pumping machinery may be expected to fall to a much lower level.

I cannot see that such a delay is unreasonable. Datia is an old town which has not expanded greatly during the war. For hundreds of years its water has been obtained from numerous somewhat insanitary wells. This ancient system long-rooted in the affections of the towns people provides water *free* for those who go to the trouble of drawing it. I cannot see the people of Datia queuing up to *pay* for piped water in their houses. If they are to have it at all they will expect to get free. I therefore think that any water supply scheme for Datia might well wait till equipment is cheaper.

Scheme 4.—Water pumped from the wells of Datia would have to be carefully treated before it would be safely used as a town supply. A number of wells would probably have to be used to provide the required quantity of water. This would require several small pumping plants and an expensive plant for filtering and treating the water. I can give no real opinion on this project as no details of the yield of the wells about Datia in the hot weather are available, but it would need constant care to keep the water in such an installation free from contamination, and I doubt whether such care would be given. In fact such a scheme is somewhat repugnant to me.

Water Supply for Irrigation

A very large combined irrigation and hydro-electric scheme known as the Bet-Huj Scheme has been put forward by the U.P. Government. This scheme will flood 25 miles of ravine land and 15 sq. miles of cultivation in Datia. On the other hand it will irrigate large areas in Indergarh and Seondha tahsils and will allow Datia State to buy up to 10,000 k.w. of cheap electric power for the development of industries in the State. The U.P. Government would also compensate all *ryots* whose land is flooded.

On the face of it this scheme may be valuable to Datia State but before accepting it a clear statement of the amount of land in the State which would be irrigated should be obtained, and it should also be ascertained whether any of flooded plain would be cultivable as the water in the reservoir recedes from it.

It is probably that Datia State could develop a valuable fishery in the area to be flooded because fish thrive best in areas subject to annual flooding especially if they are cropped between the annual floods.

The geological possibility of this scheme needs investigation. The area is, however, believed to be a granitic one and should be very suitable.

The other irrigation projects under consideration are : (1) Angouri Nadi dam with pick up weir at Mahari. This project will irrigate 3,500 bighas of land and will generate 2 million units of electricity= about 230 Electrical H.P. throughout the year ; (2) Sindh R. project. With the availability of cheap hydro-electric energy the Sindh R. could be pumped into canals so as to irrigate ¼th Datia State ; (3) Indergarh tank. This scheme will irrigate 12,500 bighas.

None of these schemes seem to have been seriously investigated so it is practically impossible to give an opinion on them.

(1) & (3) are small. If they can be carried out cheaply they are worth considering. (3) certainly sounds the more promising of them.

(2) is essentially a hydro-electric scheme and will be considered under that head.

Need for further exploration for suitable tank sites in Datia.

As a whole I think the possibility of constructing tanks for local irrigation in Datia State has been somewhat neglected. Tanks and canals in Datia should be geographically quite sound. The work involved will be mainly earthwork and excavation. The relative cost of this style of work has been greatly reduced in the last few years by the replacement of hand labour by mechanical contrivances of various types. Earthworks which were uneconomic in the past may now-a-days be very profitable especially if they enable extra land to be irrigated.

The area around Datia is very largely grass land and scrub jungle which can be flooded without doing any harm. To the North and East lie rich tillage lands at a somewhat lower level.

Many of the *nalas* rising in the grass land about Datia show the remains of ancient dams which might be worth repairing where the work would lead to a notable increase in food production. Other *nalas* rising in this slightly elevated area do not appear to have ever been dammed.

I think the State Engineer should be instructed to examine this area and put up a scheme for the construction of a number of small dams for irrigation purposes. If a programme of dam construction spread over 10 years or more were accepted it would pay the State to acquire mechanical appliances to carry out the work. If a short programme lasting only 2 or 3 years be decided on, it would probably be easier to carry it out by hand labour.

Irrigation from Sind R.

Only one big river runs within the State boundary. This is reputed to carry 700 cusecs even in the dry weather. Unfortunately it runs in a rather deep valley and would be difficult to use for irrigation. I think the possibilities of this river might be further explored. It is said to have a fall of 150 feet in 10 miles. This suggests that it might be diverted at the upper level into an aqueduct which would carry its waters out of the trench in which they flow at present and deliver them to the cultivated lands where they are needed. With such a large hot weather flow a considerable area could be irrigated without any storage dam.

SOME OBSERVATIONS ON THE CHROMITE OCCURRENCES OF NAUSAHI, KEONJHAR DISTRICT, ORISSA. BY A. M. N. GHOSH, B.Sc. (HONS.), A.R.C.S., *Superintending Geologist* AND G. H. S. V. PRASADA RAO, M.Sc., *Assistant Geologist, Geological Survey of India.* (With Plates 3 to 6.)

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INTRODUCTION

The examination of the chromite deposits of Nausahi (21° 16′ : 86° 20′) was made at the request of the Orissa Government. The chromite lodes were mapped by the junior author with the aid of prismatic compass and tape on a scale of 80 feet to an inch. The contours were superimposed on the plan by pantographic enlargement of the relevant portion of topo sheet No. 73 K/7. The general geological mapping was done on a scale of 1″=1 mile. The senior author spent a few days at Nausahi in February 1949 with his junior colleague with a view to investigating the possible extent and studying the general geological relations and the structure of the chromite lodes.

Location.

The deposits are situated near the south-eastern fringe of Baula state forest, Keonjhar district, Orissa, and are enclosed within the parallels of Lat. 21° 16′ and 21° 17′ 30″ and Long. 86° 19′ 30″ and 86° 20′. The nearest railway station, Bhadrak, is about 25 miles to the south-east of the mines. Approach from the railway station to Nausahi is by a fair-weather motor road for a distance of 36 miles. The road remains in good condition for the plying of trucks carrying the ore during the summer months. The proximity of the deposits to the iron and steel industrial centres at Jamshedpur and to the port of Calcutta has rendered them important for exploitation on a commercial scale.

For the purpose of granting mining lease, the chromite-bearing

Lessees.

area has been divided into two unequal parts of which an area of over 640 acres covering the high grounds on the north is held under lease by Mr. M. A. Tulloch. On the somewhat low grounds towards the plains an area of about 50 acres has been leased out to Mr. Sirajuddin. A forest fire line N.N.W. of Nausahi forms the boundary between the two concessions. Both the parties started work in 1944, but at the time of visit in February 1949, only Mr. Tulloch's firm was engaged in quarrying the ore. It was reported that since the operations were started by the parties, a total of 50,000 tons of chrome-ore has been raised.

Physiography.

The northern part of the area under review consists of a low range of hills which form the north-eastern scarp of a larger range roughly aligned N.E.-S.W. Round about Nausahi the hills are composed mostly of well-jointed quartzites and epidiorites and reach a maximum height of 1343 feet above the sea-level. On the south a gently undulating alluvial country with a southerly slope commences from near the foot of the hills. The low lying ground near the foot-hills is about 700 feet above the sea-level. While the quartzites form steep scarps, the epidiorites usually give rise to dome-shaped hills.

Water supply.

The area is drained by the Salandi *nala* flowing south and its tributaries of which one is the Bentkholi *nala*. The Salandi *nala* leaves the hills and enters the plains near Haddagarh (21° 17′:86° 18′), west of the mines. Enough water for the mining camp is available. Within the mining area a small dam of boulders and earth has been constructed across a *nala* joining the Bentkholi *nala*. Water stored in the dam is used for washing and concentrating the ores. There are also numerous seepages from the joints in the quartzites and subsurface springs in the plains. In the low lying area on the south the ground water level at the time of visit, end of February 1949, was found to vary between 10-15 feet from the surface.

Vegetation.

The hill slopes and valleys are densely wooded. The district maintains reserved forest in which are grown, amongst other trees, Sal (*Shorea robusta*), Sisam (*Dalbergia latifolia*) Siso (*Dalbergia sisso*), Simal (*Bombax malabaricum*), Kahir (*Acacia catechu*), *and* Mahua (*Bassia latifolia*). Thick jungles of bamboo are much patronised by elephants during the rains. No dearth of timber is felt at the mines.

Labour.

Sturdy Oriyas and aboriginal tribes are locally available for quarrying. The mining concern recruits labour from the neighbouring villages. For outside labour accommodation is provided in thatched sheds. The raising of the ore is on contract basis. For every 25 cubic feet of ore raised, the wage is Rs. 1-6-0 and for every 100 c.ft. of earth removed it is Rs. 1-8-0.

Structural features.

The chromite lodes occur in the form of steeply inclined veins and lenticular bodies of various sizes in altered ultrabasic rocks. The latter have cut across epidiorite transversely to its alignment and end against a ridge of quartzite. On account of weathering the epidiorites have given rise to dome-shaped hillocks and the chromite lodes stand out as ribs from amongst the rocks containing them. A considerable amount of erosion and removal of the ore-bearing zones appear to have taken place in recent geological times.

Method of working.

Most of the chromite is found at the lesser elevations at the foot of the hills but some occur at a height of 800 feet above the low ground on the south. The float ore is being collected. The main lodes are worked by open cast quarrying. The stripping of the overburden is done by means of picks and shovels. After a lode is exposed blasting is resorted to and the dislodged blocks are broken by sledge hammers.

Grade.

There are two types of ore one of which is lumpy and may be coarse- or fine-grained, and the other is banded and contains a certain amount of extraneous material. Samples of the coarse- and fine-grained massive ore from Nausahi were analysed in the laboratory of the Geological Survey of India and yielded the following results:—

	I Per cent.	II Per cent.
SiO_2	6·18	7·84
Al_2O_3	5 24	1·53
Fe_2O_3	11·66	11·97
Cr_2O_3	52·12	56·64
FeO	7 63	5·90
MgO	15·38	15·09
	98·21	98·97

I Represents sample of the coarse-grained ore with Cr:Fe=2·6:1

II Represents sample of the fine-grained ore with Cr:Fe=3:1

A lateritic type of chrome-ore gave 38·03 per cent. of Cr_2O_3 on analysis.

Uses of Chromite and specification.

The main uses of chromite are, metallurgical 45 per cent., refractories 40 per cent., and chemical 15 per cent. In India chromite is mainly used for refractory and chemical purposes

Normal specification for metallurgical ore calls for a grade of 48 per cent. Cr_2O_3 and a chrome-iron ratio 3:1. Lump ore is preferred to concentrates. During the last war lump ore or concentrates with chromium-iron ratio of 2·6:1 were used for making ferro-chrome. Material with still lower ratio was used for mixing with higher grade ore. There is a special process in which low grade ores high in chromium-iron ratio can be used for metallurgical purposes. Some of the Nausahi chromite have the chrome-iron ratio of 3:1 with sulphur in traces and are therefore of excellent metallurgical grade.

Requirements vary greatly in the manufacturue of refractories. but silica content should be low and percentage of iron not too high as both reduce fusion point. When silica content is 5 per cent. the ore is penalised and with over 10 per cent. it is rejected. Recently, however, it has been found that ores relatively high in silica and low in chromic oxide can be used very successfully in the manufacture of chrome magnesite bricks. Hard lump ore is preferred in the refractory industry but considerable ground ore is used for patching and protecting parts of furnaces. Chromite refractories are used in the form of bricks. crude lumps, ground ore or plastic cements. Indian consumption of the chrome ore is mainly for the purpose of refractories. There is practically no standard specification in India for the use of chromite as a refractory material. The specifications drawn by one of the chief iron and steel companies in India are as follows:

> "Concentrates (fines) are bought on the basis of Cr_2O_3 50 per cent. with an adjustment per unit above or below that figure, rejectable if below 48 per cent.; silica should not exceed 4 per cent. and FeO 24 per cent., rejectable if above these limits. Size of the ore should be below 1/16 of an inch.
>
> "Lump ore is bought on the basis of Cr_2O_3 48 per cent. with an adjustment per unit above or below that figure, rejectable if below 46 per cent. Maximum allowable silica and FeO contents are 8 per cent. and 26 per cent. respectively. Ore exceeding these limits is rejected outright. Size of the specified ore is between 1 to 2 inches."

For chemical uses, the chief requirement is high chromium content although chromite high in iron as well as in chromium is desirable as the ore then decomposes more readily during treatment. Chromite concentrates are acceptable to the chemical industry. There are chemical firms in Bombay, Mysore, Kanpur and Calcutta which require chrome ore.

Marketing and price of the ore.

Tulloch's concern at present sells the Nausahi ore chiefly to Tata Iron and Steel Company. After quarrying, the lump ore is dressed to a size of two inches and the silicate gangue removed during the process. The banded ore is being stacked at present. Chromite fragments are collected from the dumps and crushed by manual labour. The crushed ore is passed through 20 mesh sieve and then washed in pans to recover the concentrates. The concentrates are packed in gunny bags. With suitable crushing and concentrating plants, the banded ore also can be beneficiated.

The ore is transported by hired trucks to Bhadrak railway station from where it is railed to the consumers.

Prices are generally fixed by calling tenders from suppliers for the different grades. The price at Calcutta at the end of July 1950 was as follows:—

Chrome ore lump 48 per cent. basis *plus* Rs. 2 unitage. . . .	Rs. 120 F.O.B. K. P. Docks

Previous workers.

Mr. S. K. Barooah, who prospected the area on behalf of Tata Iron and Steel Company, has written a paper* on the deposits which were also examined by Mr. B. C. Gupta of the Geological Survey of India during the 1942-43 season.

GEOLOGY AND DESCRIPTION OF ROCK TYPES

The geological succession of the area in order of increasing antiquity is as follows:

Alluvium.
Laterite.
Grits carrying bands of chlorite-sericite schists with a conglomerate at the base.
Younger dolerite.
Granite.
Chromite of third generation. Sporadic silicification.
Emplacement of chromite and magnetite lodes contemporaneous with the formation of talc and serpentine.

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*"The Chromite deposits of Nausahi, Keonjhar state, Eastern States Agency" *Trans. Min. Geol. Met. Inst. Ind.*, Vol. 44, No. 2, Oct. 1948.

Chromitite.
Anorthosite.
Diallage rock and Enstatite rock.
Enstatite-peridotite (Harzburgite or Saxonite) and Enstatite-diallage-peridotite (Lherzolite).
Dunite.
Epidiorite.
Quartzites, micaceous quartzites, siliceous limestones, etc.

Quartzite, Micaceous quartzite, etc.

The oldest country rocks of the area are of sedimentary origin and consist of quartzite, micaceous quartzite, and siliceous limestones. A band of grit with a conglomerate containing pebbles of quartzite and epidiorite is present on the western side of the *nala* north-east of ·699. The grit overlies the quartzite and appears to belong to a younger formation, the age of which is at present uncertain.

The quartzite strikes between N.N.E.-S.S.W. and N.E.-S.W., and has steep dips towards E.S.E. and south-east. West of the Salandi *nala* the quartzite hills have the same direction of alignment as the strike of the formations, but east of the *nala* it is not so. The bulk of the Phuljhora Huli (·1343), the highest peak in the locality is composed of quartzites. South of Phuljhora Huli at the contact of epidiorites, the quartzites are highly crushed. The quartzites are of bluish, greyish, reddish or white colours. The bluish ones show effects of crushing, and between two big grains of quartz a zone of granular quartz is seen. Quartzite containing cordierite and sillimanite is present on the summit of ·1343 hill. In this rock sillimanite occurs as elongated needles or prisms, disjointed along their length. Cordierite has rounded outline and it shows one set of prominent cleavage. Occasionally it shows lamellar twinning. Sericite is seen interstitially. Quartzite having a staining of malachite green colour is seen north of lode No. 1 and is found to be highly crushed with the development of abundant sericite. Micaceous quartzites are seen west of ·844.

Grit having intercalations of quartz-sericite-chlorite-schist with slaty cleavage is seen to strike N.E.-S.W. The rocks have almost vertical dips at the Baisabnar *nala* north-east of ·1432. The schist contains sericite, chlorite, quartz and clinozoisite with a little amount of magnetite dust.

Joints in quartzite and grit strike N.W.-S.E., N.20°E.-S.20°W., and E.-W. Effects of considerable vertical movements along the joints are sometimes noticed as at Baisabnar *nala*. South of Phuljhora Huli, springs issue from joints in the quartzites.

Epidiorite.

The older quartzites have been intruded by epidiorite. In the epidiorite the ultrabasic rocks, containing chromite and vanadiferous magnetite deposits, occur as two bands. Epidiorite is found on the hillock south of ·699, east of ·699, south of ·1343 and on the ridges at ·937 and ·587. The rock is coarse-grained and gives rise to dome-shaped hills, the summits of which are almost barren of vegetation, although the slopes of a valley support dense jungle. The rock is composed of coarse plates of labradorite and augite. On weathering, these rocks are sometimes stained violet. Epidiorite containing free quartz is common but towards the anorthosite band containing vanadiferous magnetite, north-east of Nausahi, quartz-free epidiorite is noticed.

In the quartz-free epidiorite, the plagioclase is fresh and development of chlorite is noticed along the cleavages and boundaries of labradorite plates. The augite is completely altered into chlorite. Magnetite is either included by augite or present interstitially. Around the magnetite chloritisation is more intense.

Under the microscope, the quartz-bearing epidiorites show sub-ophitic texture. Labradorite has developed irregular crystal plates though occasional lath like forms are seen. They show both carlsbad and albite twinning. Some of the pieces are altered into sericite and zoisite. Diallage occurs as irregular plates and shows two sets of prismatic cleavage and parting. Basal partings of the salite type with schiller inclusions are noticed. Some pieces show straight extinction and the maximum extinction angle observed is 20°. Alteration starts at the borders and pieces are seen in various phases of uralitisation. Flakes of biotite show pleochroism from light brown to dark brown. Biotite has intergrown with diallage. Ilmenite occurs as an accessory and is in various stages of alteration into leucoxene. Sphene is seen to develop at the expense of ilmenite. A few blebs of interstitial quartz are present, but in more acidic types bigger grains are noticed.

Ultrabasic rocks containing chromite lodes.

Ultrabasic rocks, containing chromite, occur as a band in epidiorite. The band is broad near the centre and narrow at the southern and northern ends. In the saddle south-east of Phuljhora Huli, the band abuts against quartzite. Here talc-schists strike E.N.E.-W.S.W. and dip at 75° to 80° towards S.S.E. On the south the ultrabasic rocks are silicified. The junction between the epidiorites and the band of ultrabasic rocks appears to be a faulted one. Effects of crushing are noticed in epidiorite near its contact on the western side of chromite lode No. 5. The yellowish-green granular serpentinous material present at the junction of ultrabasic rocks and epidiorites in Tulloch's upper quarries, is a sheared epidiorite containing bent and strained plagioclase laminae, hornblende and serpentine. Sometimes the junction is obscure. The majority of the ultrabasic rocks, specially the ones near the chromite lode, are not in their pristine state. The alteration products usually preserve the outlines of the original minerals and the texture so that their original parentage can easily be inferred.

Diallage rock.

South-south-east of Phuljhora Huli, ascending southward from the *nala*, a compact, hard, yellowish-green rock is noticed. This rock consists essentially of diallage with schiller inclusions along the vertical cleavage. This mineral is now almost replaced by epidote and hornblende. Along the outline of diallage plates hornblende is noticed at the border and epidote grains at the centre. Sphene has developed at the expense of ilmenite which is now left behind as leucoxene.

Just adjacent to these rocks and away from the talc-schists there is an exposure of a light coloured rock (anorthosite?) traversed by anastomosing veins. Under the microscope the rock is found to be made essentially of labradorite, altering into zoisite with veins containing hornblende, chlorite and epidote. Sphene is formed at the expense of ilmenite.

Lherzolite.

Megascopically lherzolite is a coarsely crystalline rock having a greyish-black colour. This rock occurs as a minor band by the eastern side of the *nala* north-east of ·699. The rock consists of diallage, bronzite and olivine. Olivine is poicilitically included in diallage and altered into serpentine. Diallage also includes bronzite. Diallage shows lamellar twinning and characteristic longitudinal striations with schiller inclusions. The mineral is positive with 2V=56°. Bronzite shows pleochroism from colourless to pink. The mineral is negative having 2V=72°. Olivine which is completely altered into serpentine is studded with chromite. A few rectangular flakes of biotite are seen in diallage.

Harzburgite or Saxonite.

Saxonite is the predominant rock in the ultrabasic band. It occurs in proximity to the chromite lodes and is known only by the alteration products which, however, preserve the original texture. Exposures of the rock are located on the south-western slope of the hill north-west of Nausahi and by the western side of lode No. 13. On the weathered surface the platy nature of the original mineral can be seen. This rock is compact and light green with white streaks. Talc has completely replaced enstatite and serpentine has replaced olivine. Large crystal outlines of enstatite with two sets of cleavage at right angles are seen to enclose grains poicilitically showing outlines of olivine. Subhedral to anhedral chromite is noticed.

Enstatite-bronzite rock is found on the elevation east of Sirajuddin and Co.'s pillar No. 4 and on the south-eastern flanks of the hill north-west of Nausahi. Here absolutely fresh rocks are present as also types showing various stages of alteration into talc. When fresh, the rock has a resinous lustre and bottle green colour. On weathering, the lustre gradually fades away and finally grey talc preserving the original platy nature of the rock results. All these stages of alteration can be seen in the elevated ground east of Sirajuddin and Co.'s pillar No. 4.

Under the microscope the fresh rock shows interlocking plates of enstatite and bronzite with a few grains of accessory olivine. Enstatite has usually one set of prismatic cleavage and shows straight extinction. The mineral is positive with 2V between 82°-84°. Bronzite has a higher refractive index than enstatite and has one or occasionally two sets of cleavage. The mineral is negative with $2V=74°$. Occasionally olivine is seen included either by bronzite or by enstatite. The rock is highly fractured and filled by talc. Euhedral chromite is seen along those cracks or along the cleavage and is completely sheathed by talc. When the rock is altered, talc is seen preserving the original cleavage and outlines of the two pyroxenes.

Dunite.

Dunite is now almost completely altered into compact yellowish-brown serpentine. It is found in Tulloch's lower quarries and in the three pits south of lode No. 14. The rock is compact and contains disseminated chromite. Under the microscope a few relic pieces of fresh olivine are noticed. The rest of the rock is composed of serpentine that has resulted from olivine.

Chromitite.

Chromitite consists chiefly of chromite with silicate gangue. It is found in Tulloch's upper quarries. The banded variety consists of thin bands of chromite alternating with white bands of talc and greenish translucent serpentine. Under the microscope the chromite is seen developing crystal outlines of cube, octahedron and dodecahedron. Chromite is deep cherry red in the middle and has black opaque borders. The crystals are fractured and filled with talc. "Accumulation structures" of chromite completely enclose talc, serpentine and chrysotile pockets. The compact greenish translucent mineral with greasy lustre is williamsite which is after enstatite. The original pyroxene cleavage and the crystal outlines can be easily traced. Outlines of olivine, now filled by serpentine, can also be seen.

Rocks containing vanadiferous magnetite.

Silicified ultrabasic rocks are seen in the plains south-west of Nausahi. Vanadiferous magnetite occurs in a three-mile-long band of ultrabasic rocks mainly composed of anorthosite. The band starts from the northern slopes of ·587 and continues east of ·937 and ·1343 and abuts against micaceous quartzites at ·604. There are numerous thick bands of magnetite occurring all along the length of the band. On weathering, the magnetite lodes stand out as ribs. At ·604 a thick lode 600 yards long and 40 feet wide is enclosed by talc-chlorite-schists. Here the strike is roughly east-west with high dips towards south. On the eastern slope of the ridge east of Phuljhora Huli also, lodes of over 500 yards in length and 20 feet in width are seen associated with talc-chlorite-schist and anorthosite. At the contact of this band with epidiorite, the latter has been altered into green chlorite-schists. In the saddle north-west of ·587 fresh anorthosite is seen associated with magnetite lodes. This is a medium-grained leucocratic rock containing visible skeletons of magnetite up to five millimetres in length, giving the impression that magnetite is related to anorthosite. Under the microscope, the rock is seen to be composed of coarse irregular crystalline plates of plagioclase whose composition varies from labradorite to bytownite. Magnetite occurs as skeletons and is found to invade plagioclase plates. It is completely enclosed by chlorite. Grains of epidote and zoisite are present throughout the plagioclase pieces but their number increases towards the magnetite skeletons. Away from the magnetite lodes, towards the epidiorite contact, pyroxenites are noticed.

Granites are seen in the low lands south of ·410. Fine-grained dolerites are seen intruding into the granites. Laterite occurs at Bangur (21° 15′:86° 19′) and south of Nausahi. Locally it is used as building stone.

VARIETIES OF CHROME ORE

Three generations of chromite are recognised. The earliest is coarse-grained and intersected by a finer grained type which, in its turn, is cut by a still finer grained chromite. Megascopically the following types of ore are noticed:

1. *Banded ore.*—It consists of moderately disseminated ore grains arranged in layers which are, however, not very distinct. The schlieren bands are like the schlieren plates in a crystal and the arrangement of chromite grains is often found wavy.

2. *Massive ore.*—This is either coarsely crystalline or fine-grained or both. Usually in the lodes, the coarse- and fine-grained are mixed up, the coarser variety predominating in the lodes (Nos. 10, 11, 12, 13 and 14) situated in the lower belt and the finer predominating in the rest situated in the upper belt. The coarsely crystalline variety consists of interlocking grains of chromite measuring up to 4 millimetres in size. They are usually bounded by crystal faces. The coarse crystal aggregates are cut by veins of fine-grained ore. Under the microscope, these fine-grained veins are seen to be densely distributed and they consist of euhedral to sub-hedral unfractured chromite in a ground mass of talc and serpentine.

3. *Spotted or pitted ore.*—This is a transition type between the banded and the massive ores. The silicates, now altered into serpentine or talc, are scattered as oval or round clots in a predominantly massive ore, producing a spotted appearance. On weathering, these silicate gangue fall away causing a pitted appearance.

4. *Nodular ore.*—This consists of fine-grained chromite which occurs as nodules in massive ore or in a silicate ground mass adjacent to lodes of massive ore. On weathering, these nodules fall away from the host rock and produce a pitted appearance.

5. *Float ore.*

6. *Placer sand.*—Fine glistening chromite sand with metallic lustre is seen in the *nala* courses.

7. *Lateritic ore.*—This is reddish-brown to bluish-black compact ore with vitreous lustre. No individual grains are seen except as a compact mass.

8. *Disseminations.*

DESCRIPTION OF ORE DEPOSITS

The topmost deposit is situated at an altitude of 1,050 feet above sea-level and the lowest ones are at 200 feet above sea-level. Except the lodes situated in the saddle south-east of Phuljhora Huli and the southern slopes of the hill south-east of ·1343, all are easily accessible. The following structural types are recognised: (1) Disseminated, (2) Schlieren banded, (3) Lenses or bands controlled by shear planes and (4) Sack-form.

Deposits in the saddle south-east of ·1343.

Lodes Nos. 1, 2 and 3 are located in the saddle south-east of ·1343 at an altitude of 1,050 feet above the sea-level. The difference from the valley level is about 500 feet. On weathering of the softer material, the lodes stand out as ribs. The lodes strike roughly east-west with a steep dip of 70° towards south. These three lodes are connected with one another and only a few pieces of talc are noticed in between the lodes. From lode No. 3 the ground rises to lode No. 1 North of lode No. 1, debris of talc is present and the talc-schist—quartzite junction is 50 feet from the lodes. It is possible that these three lodes may be protuberances of single sack-form deposit. The chromite is fine grained and has dull reddish brown colour.

Deposits on the southern flank of hill south-east of ·1343.

Lodes Nos. 4 and 5 which are 200 feet apart are situated on the southern slope of the hill south-east of ·1343, about 300 feet above the valley level. In between these two loads there is a small pocket of chromite. Lode No. 5 is at the junction of the epidiorite and the ultrabasic rocks. Both the hanging and foot walls are in talc-schists. The trend of the lode is N.N.W.-S.S.E. and it dips at 55° towards east-south-east. A ten-foot-deep trial pit shows persistence of ore at depth. About 90 feet north of lode No. 4, there is a pocket of chromite. The rocks adjacent to the lodes show crushed phenomena. Small pockets of chromite are observed away from the lode in talc-schists.

Lodes in Tulloch's upper quarries and north-west of them.

Under this heading lodes Nos. 7, 8 and 9 are dealt with. Lodes Nos. 8 and 9 are on the sheared junction between epidiorites and the ultrabasic rocks. The trend of the lodes is N.N.W.-S.S.E. and it becomes north-south in lode No. 7 and east-west at the south-eastern corner of Tulloch's upper quarries. Lodes Nos. 8 and 9 are connected with each other by a thin feeder channel. A road separates lodes No. 7 and No. 8 and positive proof of their connection is not available. But lode No. 8 swings westward at its northern end and most probably is connected to lode No. 7. North of lode No. 7 a trial pit was sunk in the thick float, but no lode could be traced. A trial pit, up to 20 feet in depth. in lode No. 7 proved that it continues in depth.

The strike of the lode at the south-eastern end of Tulloch's upper quarries is east-west. The hanging wall of the lode itself carries banded ore underlain by massive fine-grained ore. The banded ore strikes east-west and dips 45° towards north. The massive ore does not show jointing prominently and rests on grey talcose foot wall which is highly jointed. The banded variety is nine feet thick. At the western end of the quarry the ore-body gets squeezed; the banded variety, now almost vertical, borders massive ore and together they have a thickness of one foot. They, however, broaden out in the next quarry on the west. Here the banded variety strikes east-west and dips 60° towards north. It is seen on either side of massive ore. In this quarry the hanging wall is in yellowish-green granular serpentinous material (sheared epidiorite) which crumples in the hand, and the foot wall is in talc. The north-western extremity of this lode has also been opened up. Here the chrome ore has thinned out considerably and the contact with the country rock is highly crushed. In such sheared contacts anthophyllite has developed with its blades showing an upward drag effect against the ore body. At this end of the lode the banded ore is absent and it was probably pinched off during the intrusion of the massive ore. Here the ore thins out and a feeder channel of about two inches in thickness is seen connecting this lens with the next one. The entire lode No. 8 consists of massive ore. On the hanging wall side there is a thin zone containing yellowish-green granular serpentinous material (sheared epidiorite) which is ferruginous on the surface. On the foot wall side talc rocks are highly jointed. Anthophyllite is present at the contact.

Lodes in Tulloch's lower quarries.

The trend of lodes Nos. 10 and 11 is approximately north-south and the dip is eastward. The area containing lode No. 10 and the lower portions of lode No. 11 has a two to five feet thick layer of float ore overlain by soil. Both the hanging and foot walls are in serpentine. The junction between the lode No. 10 and the country rock is sheared. The plane of shear dips at 70° eastward. All the ore is of massive variety. In the hill section of lode No. 11, the junction of chromite lode with the country rock is highly sheared. The shear planes on either side of the lode dip at angles of 80° away from one another. Here the chromite lode throws apophyses into the surrounding serpentine. In the low lands north of lode No. 10 trial pits revealed a layer of float ore on talc-schists.

At the southernmost end of Sirajuddin's main quarry the lode consists of massive ore containing aggregates of chromite crystals traversed by veins of fine-grained ore. The lode strikes N.10°W.-S.10°E. and dips N.80°E. at 65°, with the serpentine on the hanging wall and talc-schists having pockets of serpentine in the foot wall. In the foot wall, the country rock is highly jointed and replaced by chrome ore to form low grade ore. The joints dip N.80° E. at 40° under the high grade ore. At the contact of the hanging wall the lode shows effects of chilling, the ore becoming glassy and non-crystalline. The chilled zone is four to six inches in thickness. Further north the hanging wall of serpentine is replaced by earthy looking khaki coloured talcose rocks. These talcose rocks are friable and show effects of crushing at the contact. The hanging wall shows some banding provided by chromite and talc. The faces of the chromite lodes carry thin slices of slickensided talc. Here, there are inclusions of dunite rock in the lode. In the foot wall the country rock is replaced by the chromite and replacement structures are seen. At this place a feeder channel connecting the lode on the hill is seen. Just at the contact of the chromite lode the serpentine has been changed into talc. The foot wall shows pitted appearance due to falling off of nodular ore. Further north the lode swings westward and narrows down to feed another lode having an east-west trend higher up on the hillock to the west. The difference between the top and bottom portions of the quarry is about 45 feet and the lode is noticed to continue at depth.

The hill north-west of Nausahi contains two more important lodes (Nos. 12 and 22) on its western and eastern sides. The lodes strike roughly N.N.W.-S.S.E. The hanging and foot walls are both in talc. Besides there are about eight small exposures distributed between the above two lodes. The north-eastern and north-western slopes of this hill are full of float ore. The float of lode No. 12, as is seen in the quarry near the fire line, is from 2½ to 9 ft. thick. Big and small boulders of chromite that have fallen out from lode No. 22 are seen to its east.

There are many small lodes in the undulating country north-west, west and south-west of Nausahi. They are visibly shallow. Some of the lodes, as in the slopes just adjacent to Sirajuddin's main quarry, have both their hanging and foot walls in the serpentine. Here the lodes die out within 15 feet from the ground surface. South-west of Nausahi there are low grade ferriferous lodes which have both their hanging and foot walls in laterite. Except these lateritoid ores the rest of the lodes situated in the plains have been exhausted by Sirajuddin's company.

ORIGIN AND STRUCTURE OF THE CHROMITE LODES

From the distribution of the rocks given above, it is seen that the compact yellowish-brown serpentine with relics of olivine is seen only in the lower horizons where the veins die out at shallow depths. At Sirajuddin's main quarry, even though the rocks above are talcose with pockets of serpentine, which have resulted from the alteration of enstatite-peridotite, at depth yellowish-brown serpentine is noticed. The dunite, which is now practically altered into massive serpentine, is confined to the low ground on the south, where it is restricted to the marginal portions of the band of enstatite-peridotite. Dunite is not seen anywhere in the high ground on the north. The chromite, noticed in the dunites, is found to continue into the enstatite-peridotite. Hence it is probable that in mining operations, when yellowish-brown serpentine is met with, the lodes may die out within shallow depths.

The chromite deposit, in so far as it indicates the monomineralic segregation of an ultrabasic magma, is also a primary differentiate and in regard to the size, form, structure, etc., is dependent upon the physical condition of the melt when it forced up its way as already differentiated ore magma. In the study of the origin of chromite deposits, distinction must be made between the time of differentiation of chromite magma and its emplacement as an ore body. The crystallisation might have been initiated at an early magmatic stage but continued over a wide range of time with progressive enrichment. The emplacement of the ore seems to have taken place, in large part, after the main period of rock intrusion and just before or contemporaneous with the period of talc and serpentine formation.

The banded ore consists of alternate layers of varying amounts of disseminated ore and silicate gangue represented by talc and serpentine. This ore, designated by the name 'chromitite', also owes its origin to magmatic segregation. The high grade massive ore occurs in the centre bordered by the banded chromitite on either side or penetrating the banded ore indicating its intrusive relationship with it, as can be clearly seen in the south-eastern portion of Tulloch's upper quarries.

In these deposits the relation of the ore bodies to the N.N.W.-S.S.E. and E.-W. shear zones can be seen from the map. The intersection of the two shear zones, as seen at Tulloch's upper quarries and Sirajuddin's main quarry, is the locus of large ore bodies. The other deposits are located along the junctions of enstatite-peridotite and epidiorite. The alignment of chromite lodes along shear zones and junctions suggests structural control of these over ore deposition. The overlapping and crosswise direction of the ore lenses, and contact effects such as chilling, indicate that they have been intruded into the weak shear zones.

The primary chromite segregation, mass crystallisation, settling and solidification into large ore bodies do not, however, exclude the possibility that chromite melts under pressure and wanders off into already solidified or partially solidified rock zones. It can thus produce injection-like ore bodies.

Connection by feeder channels of one lens with the other, actual cutting of the banded ore by massive ore, the relation of the shear zones to ore lenses and non-restriction of deposits to one rock type, only argue against the deposits having been formed by magmatic segregation *in situ*. Instead, the ore magma was separated elsewhere by magmatic segregation and was forced into the already solidified country rocks. This can be seen from the inclusion of fragments of dunite in the chromite itself. The movements accompanying serpentinisation and formation of talc, fractured and displaced the ore body. Hence the time of emplacement is dated after the intrusion of the parent rocks and towards the beginning of, or contemporaneous with, the formation of serpentine and talc. In other words a chromite-rich magma segregated at depth and was injected into the fractures in already consolidated rocks above without appreciably replacing them.

CYCLE OF IGNEOUS ACTIVITY AND EMPLACEMENT OF THE ROCK TYPES

A short outline of the cycle of igneous activity of the area may be given. Within a compact area as the present one, the intimate association of kindred types of basic and ultrabasic rocks suggests consanguinity at first sight. Genetic relationship of the different types may be inferred by the presence of olivine in the various types of ultrabasic rocks and of diallage in them, as well as, in the epidiorite. The felspar in the epidiorite is a basic plagioclase of the labradorite variety, very nearly the same as that of the anorthosite. The evolution of such rocks as epidiorite (gabbro), anorthosite, pyroxenite, peridotite and dunite, therefore, may be explained by magmatic differentiation at various stages in the cooling history of an original basic magma. Given sufficient time and favourable conditions of temperature and pressure, gravitational separation of layers of different densities and fractional crystallisation, which play a prominent part in differentiation in a magma chamber, can help such a magma to separate into olivine-free and olivine-rich fractions. It is likely that the anorthosite rock, in the present instance, has been formed by the local segregation of olivine-free basic magma, the bulk of which crystallised later as a normal gabbro, sometimes enriched in quartz. The amphibolisation of pyroxenes in the gabbro has given rise to the epidiorite.

The olivine-rich fraction contained chromite in the chromite area and it is possible for the heavier chromite melt to segregate and settle at the bottom where chromite of an earlier generation may have crystallised. Fractional crystallisation of the residual olivine-rich melt, on the other hand, is capable of giving rise to the olivine-pyroxene rocks (peridotites) and dunites depending upon the relative concentration of the Mg and Fe components during cooling and crystallisation. Although enstatite in the olivine-enstatite rock may be a product of crystallisation differentiation, formation of a portion of the enstatite as a result of the reaction of olivine of an earlier generation with the residual magma, enriched in silica, H_2O and CO_2 at a late magmatic stage, may be regarded as a possibility. The pronounced alteration of the enstatite-peridotites into talc and serpentine is suggestive of such alteration by hydrothermal action resulting from the enrichment of the residual magma in gaseous substances. Chromite of a later generation may be associated with the period of serpentinisation. It is likely that low temperature hydrothermal alteration proceeded still further bringing about epidotisation and silicification of some of the rocks at the paulopost stage.

It is, therefore, possible to visualise the gravitational separation of an original basic magma into layers of different densities, the heaviest portion containing chromite and magnetite coming at the bottom of the magma chamber and the lighter upper fraction being represented at present by epidiorite and an intermediate fraction by ultrabasic rocks. Whether differentiation proceeded still further to give rise to rocks of the granitic or grano-dioritic suite can be ascertained by continuing the mapping further afield. Orogenic movements, following the upheaval of the quartzites, caused an intrusion, first of the upper layer of the basic material, into the folds of the quartzite in the shape of laccolithic bodies. This was followed by an injection of dyke-like bodies of ultrabasic materials into the basic rocks themselves. At a later stage the chromite and magnetite were forced up into the ultrabasic rocks along shear zones. The cycle of igneous activity, in this area at least, came to an end by low temperature hydrothermal alteration of the basic and ultrabasic rocks during which some of the chromite of a later generation may have been precipitated.

Further search for chromite and magnetite, should, therefore, be made in the ultrabasic rocks within the epidiorites elsewhere in that region.

RESERVES

With the remarks in the preceding chapters in view, an average depth of about 50 feet was assumed in the calculation of the reserves. Some of the important lode dimensions and tonnage are given in the following table:—

Lode Number.	*Length.* (feet)	*Width.* (feet)	*Tonnage.*
1	100	16	9,600
2	160	10	9,600
3	190	12	13,680
4	100	10	3,000
5	80	20	4,800
6	40	10	1,200
7	120	50	18,000
8	340	25	25,500
9	360	35	37,800
10	180	16	2,880
11	80	10	800
12 (*a*)	140	15	6,500
12 (*b*)	150	10	4,500
13	200	45	2,700
14	160	15	7,200
15	30	10	300
16	30	15	1,350
17	30	10	300
18	40	10	400
19	60	10	600
20	40	15	600
21	35	30	9,600
22	160	20	9,600

Besides the above reserves the float ore and the other minor pockets yield nearly 15,000 tons. The minimum reserves will, therefore, be of the order of 200,000 tons. Detailed prospecting by drilling may reveal additional tonnage.

Detailed investigation of the vanadiferous magnetite was not attempted. Since the vanadium content is very low, there is no market for these ores at present. From the preliminary investigation, it can be safely concluded that its available tonnage will be of the order of 500,000 tons.

EXPLANATION OF PLATES.

PLATE 3. Fig. 1. Banded chromite dipping north at 45°. South-eastern end of Tulloch's upper quarries.

„ Fig. 2. Banded chromite dipping north at 45°. In the middle quarry of Tulloch's upper quarries.

„ Fig. 3. A block *in situ* of banded ore cut by massive spotted ore-stick resting on non-banded spotted ore; note holes due to weathering and falling out of silicate nodules.

„ Fig. 4. Highly crushed and folded talcose rocks underlain by bent chrome ore gradually passing into vertically dipping chrome ore. The stick end rests on a shear zone with banded ore on either side of massive ore which was pinched out upwards. Western end of the south-eastern portion of Tulloch's upper quarries.

PLATE 4. Fig. 5. Here the chrome ore has thinned out considerably and has a long shear zone where anthophyllite has developed. The whole lode is of massive high grade ore. Stick points to contact of shear zone. North-western extremity of Tulloch's upper quarries.

„ Fig. 6. Sheared junction of chromite lode and country rock, dipping 80° away from each other. Stick rests on shear contact. Hill section in Tulloch's lower quarries.

„ Fig. 7. Chilled facies of chromite at the contact with serpentine on the hanging wall. Upper end of the stick points to the chilled zone. Southern extremity of Sirajuddin's main quarry.

„ Fig. 8. Highly dipping chromite lode. The stick rests on crystalline high grade massive ore. The man is standing on jointed low grade ore dipping eastwards under the high grade ore. Southern extremity of Sirajuddin's main quarry.

PLATE 5. Chromite deposits of Nausahi, Keonjhar district, Orissa.

PLATE 6. Geological map of the area around Nausahi, Keonjhar, Orissa.

A NOTE ON AN EARTHQUAKE IN THE ANDAMAN ISLANDS (26TH JUNE 1941). BY A. G. JHINGRAN, M.SC., PH. D., *Superintending Geologist, Geological Survey of India,* (With Plate 7.)

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INTRODUCTION

An earthquake shock of fairly severe intensity occurred at about 16 h. 23 m. (Indian Standard Time) on 26th June 1941 in the Andaman Islands. Although its destructive effects were confined to the Islands, it was felt over a wide area covering the eastern and southern regions of India and was recorded, according to the newspaper reports, by observatories as far apart as London and Ottawa. It is intended to record, through this paper, all the available details of the shock.

DESCRIPTION OF THE SHOCK AND ITS EFFECTS

The shock was felt very distinctly all over the Andaman Islands, even those driving cars did not fail to notice it. Some persons were thrown out of chairs, and subsequently they found it difficult to stand up. Some persons standing in the open were obliged to sit down and hold some substantial object. A general sense of alarm was developed.

Although the tremors continued for a long time the main shock lasted for about a minute and caused motion which, according to the reports from the various observers, was predominantly in a west-east direction.

The effects of the shock were quite ruinous in the Andaman Islands. Most of the masonry structures in and around Port Blair suffered badly. Numerous cracks were developed in the walls and roofs; parts of certain buildings got detached from the main blocks, and some buildings completely collapsed, while the roads were badly cracked. Bridges, embankments, sea-walls and jetties also suffered extensive damage.

The shock was possibly most intense near the Baratang Island (about 35 miles north of Port Blair) from where an observer[1] reports that giant trees with girths of about 5 ft. at breast height, either fell down straight away or got bent to an angle of about 30° and later on fell down. He also records that the earth opened and closed to an extent of several feet and was finally left open about a foot wide.

An observer[2] from Shoal Bay Creek (between lats. 11° 48′ and 11° 55′ and along long. 92° 44′ approx.) also records very destructive effects. He states that a tram line running east to west was pulled out from its position in two places over lengths of about 100 ft. each, and thrown down to the south side of the embankment by 5 ft. The bridge in the creek and the Douglas Jetty canted forward and subsided by about 2½ ft. The embankment of the line also subsided by about 2 ft. Numerous cracks and fissures are reported to have been formed all along the stream banks in the camp area.

The phenomenon of vents and gushing out of water and sand is reported to have occurred at several places on a moderate scale.

An observer (Assistant to the Chief Forest Officer, Andaman Islands) states that the Islands of Colebrooke, Baratang, Porlob and Bajalungta have subsided by at least two feet. His conclusion is based on observations that the areas which used to get dried up at low tides, before the earthquake, are now covered with permanent water. Soundings taken in the passage between Prolob Island and Bajalungta revealed a subsidence of at least five feet.

The damage on the western coast of the Islands seems to have been more extensive. The Assistant to the Chief Forest Officer observes that extensive areas on the Islands of Laikera Lungta, Spike, Bilita Talakaicha, etc., near Port Anson in the Middle Andamans, have got stripped of all vegetation and soil, exposing bare rocks over wide areas. According to the same observer the violence of the shock decreased from Port Anson towards Entrance Hill in direct proportion to the distance.

[1] Syed M. Tyeb, Forest Ranger, Andaman Forest Department.

[2] C. A. Belappa, Forester, Port Blair.

Intensity of the Shock

Thirty-nine reports, besides those from the Assistant to the Chief Forest Officer, have been received from various observers. Of these, six are from meteorological observers in India, one from Burma, and the remaining 32 from the Andamans. Out of the latter, 20 are from observers in Aberdeen, Port Blair and its neighbourhood, and 12 from other places spread over the Islands. On analysing these reports it is found that the average intensity of the shock on the Islands was about VIII on the modified Mercalli scale[1], and that it tended to go slightly higher up around Baratang Island, and Shoal Bay Creek, north of Port Blair, and near Port Anson on the western coast of Middle Andaman. At Rangoon, as reported by an observer[2], the shock was hardly felt, not being noted by people walking out of doors, and the intensity may have been about II. It is very much regretted that the number of observations is not large enough to allow an attempt to draw isoseismal lines.

Number of Shocks and their duration.

The majority of observers felt that there was one major shock which lasted for about a minute or a little more. Some observers estimated that the shock lasted for nearly two minutes or even more, the maximum estimate being 4½ minutes. Some of the observers thought that there were two or perhaps three shocks which occurred one after the other in quick succession.

Direction of Movement

The observers differ widely with regard to the direction of the shock as judged by the fall of objects, the swing of hanging lamps, etc., the directions mentioned being east to west, south-east to north-west, south-south-east to north-north-west, north to south and south-west to north-east. A majority of the people, however, were of the opinion that the movement was from east to west, which is perhaps more likely to have been the principal direction of movement, the epicentre being to the west of the Andamans (*see* page 304).

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[1] The scale that was adopted by the party of the Geological Survey of India which investigated the Bihar-Nepal earthquake of 15th January 1934, and which is given in table IV on pages 12 and 13 of the Memoir describing that earthquake (Vol. 73, 1939). It may be recalled that this modified scale has intensities ranging from I, where the shock is noted by instruments only, to X, where the shock is very disastrous, with ruin to many buildings, and great loss of life, cracks in the ground and landslips, etc.

[2] Dr. E. L. G. Clegg, Superintending Geologist, Burma Geological Department, Rangoon.

The Seismological Data

In the following table is given the seismological data collected from the various observatories in India.

Table I.—Seismological Data

Observatory	Time (I. S. T.)	Duration (approx.)	Epicentre		Other Details
			Distance from the Seismogram	Co-ordinates (tentative)	
	h. m. s.				
1. Agra	ep—17.26.31 ip—17.26.41 S—17.30.29 F—21.58. 0				
2. Alipur, N. Compt.	P—17.24.43				The coupling bar was overthrown after 'P', no other phase was recorded.
S. Compt.	P—17.24.48 S—17.26.43 S—17.25.25 F—Not clear		712½ m.		Very great epicentral region, probably in the neighbourhood of the Andamans.
3. Colaba	P—17.26.38 S—17.30.26 F—21.37. 0	4.10	1,470 m.	12°0′N[1] 92°5′ E to the west of Andamans	h. m. s. Time at origin—17.21.55
4. Dehra Dun	17.26	2.34	1,600 m.	..	..
5. Kodaikanal	17.25.30	4.5	..	..	Time of finish 21 h. 20 m.

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[1] Revised position; the first calculations placed the epicentre at 13°5′ N: 93°7′ E in the neighbourhood of the North Andaman.

Epicentre

The calculated distance of the epicentre from Alipur (Calcutta), Dehra Dun and Colaba (Bombay) are stated to be 712½ m., 1,600 m. and 1,470 m. respectively (*see* Table I, p. 303) The intersection of the arcs described with Alipur, Dehra Dun and Colaba as centres and distances mentioned above as radii respectively should give the epicentre or the epicentral region. On construction (*see* Plate 7) it is noted that the points of intersection of the arcs drawn around Colaba and Dehra Dun and of those around Colaba and Alipur, fall to the east of Andamans, the former near Barren Island, and the latter about 115 m. N.E. of the north end of the Andamans. The arcs scribed around Dehra Dun and Alipur, however, do not intersect. They come nearest to each other at a place in the Gulf of Martaban about 350 m. N.E. of Middle Andaman. Thus only two apices are available and a distinct triangle of error is not formed. It is thus, difficult to get the exact position of the epicentre from this construction.

According to the revised calculations of the Colaba observatory (*see* Table I, p. 303) the epicentre is located at 12° 0′ N.: 92° 5′ E., which falls about 40 miles to the west of the Andamans.

As previously stated the number of observations are limited and it is not possible to draw isoseismal lines from which the position of the epicentre could be determined and the calculated position confirmed. The reports from the observers, however, do show that the intensity of the shock was more severe on the western coast of the islands, and possibly the region of maximum destructive effects was near Port Anson area. This indicates the possibility of the epicentre being off the western coast of the Islands, not far from Port Anson, which agrees with the position determined by the Colaba observatory, *i.e.*, 12° 0′ N.: 92° 5′ E., and this may thus be taken as the correct location of the epicentre.

Depth of Focus

No accurate observations are available regarding the direction of the wave path or the duration in seconds of the preliminary tremor at a place near the focus (Omori method). Mallet has suggested that the depth of focus is obtained by multiplying the distance between the epicentre and the meizoseismal line (where the horizontal component of the intensity is maximum) by $\sqrt{2}$ or 1·414. The epicentre in this case being in the open sea it is difficult to determine the meizoseismal line. Considering that the ruinous effects were confined to the Andamans, and that the shock was felt over a wide area in India and Burma, it may be inferred that the intensity of the shock rapidly declined away from the epicentre, and from which it may be further concluded that the shock originated at a comparatively shallow depth.

Foreshocks and aftershocks

No shock with an epicentre in the region around the Andaman Islands was recorded within about a year and a half before the earthquake under report. There were, however, quite a large number of aftershocks, details of which are given in Table II. These figures are based on the monthly reports that are published by the Meteorological Department in *Current Science*[1] (Bangalore).

From a study of this table it is noted that after the main shock on 26th June, 1941, two shocks of moderate to slight intensity were felt per day for two days, *i.e.*, on 27th and 28th June. Then the number was reduced to one on alternate days, and after another four days it got further reduced to one in about a week's time, five shocks having been felt in the month of July 1941. The interval was increased to about 10 days in August, during which month only three shocks were felt. After this the disturbances ceased, no shock having been felt in September and the following months. There was, thus a gradual decrease in the seismic activity in the area until it ceased finally.

TABLE II.—*Details of Aftershocks*

Date	Intensity	Time of origin I. S. T. h. m.	Epi central distance (in miles)	Location of Epicentre.	
				Tentative Co-ordinates	Neighbourhood
1941 June 26	Very great	17.22	1,470	12°0′ N. : 92°5′ E.	West of Andamans
27	Slight	13.3	1,450		
27	Moderate	14.2	1,490		
28	Slight	0.34	1,520		
28	Slight	23.25	1,520		

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[1] *Current Science,* (Bangalore), Vols. IX, X, XI, (1940-1942).

TABLE II.—*Details of Aftershocks*—contd.

Date	Intensity	Time of origin I. S. T. h. m.	Epicentral distance (in miles).	Location of Epicentre	
				Tentative Co-ordinates	Neighbourhood
1941 June 30	Moderate	23.54	1,420	13°5′ N. : 93°7′ E.	Near North Andamans
July 2	Slight	8.12	1,450		
9	Slight	6.9	1,550		
14	Slight	7.32	1,450	11°7′ N : 93°0′ E.	Near Andamans
18	Slight	5.1	1,500		
22	Slight	1.49	1,450		
August 10	Moderate	3.48	1,510	Near 10°0′N. : 94°0′ E.	South of Andamans
19	Slight	21.49	1,710	Near 7° N. : 96° E.	East of Nicobar Is.
30	Slight	22·15	1,430	Near 14°5′ N. : 94° E.	Near North Andamans

GENERAL DISCUSSION

An earthquake which caused ruinous effects in the Andamans comparable to the present one occurred about 60 years ago on 31st December, 1881[1]. That shock was of very severe intensity, and was felt over a large area covering nearly 2,000,000 sq. miles, including Atchin in Sumatra, lower Burma, lower Bengal, Orissa, South India and Ceylon. The 1941 earthquake was possibly felt over a considerably smaller area, the north-western limit in 1881 having extended up to about Chunar near Benares, whereas in 1941 it was only as far as Faridpur in Eastern Bengal. There is no precise information regarding the southern limit in 1941. In the north, however, the 1941 earthquake was felt up to Silchar in Assam, but in 1881, the limit was only up to Lower Bengal.

So far as the destructive effects are concerned, the available information goes to show that the 1941 earthquake has been more ruinous, there being greater damage to the masonry and forests. The tidal effects in 1881 were quite extensive, large sea-waves, some measuring about three feet from crest to hollow, having been formed over a good part of the Bay of Bengal. Full data regarding the forced waves in the present case have not been available, but there is no doubt that extensive waves were forced at least around the Andaman Islands. It is, however, likely that the waves were more conspicuous in 1881, which is easily understood when it is noticed that the epicentre of the 1881 earthquake was in the open sea, about 300 miles north-west of the Andamans (*see* Plate at end), the epicentre of the present earthquake being apparently only 40 miles west of the Islands.

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[1] Oldham, R. D., *Rec. G. S. I.*, XVII, 1884, "Note on the Earthquake of 31st December 1881", pp. 47-53.

Examining the location of the 1941 epicentre, it is to be noted that it occurs close to the western edge of the continental shelf around the Andamans, where the bottom of the sea is deep and the slope is possibly steep. M. de Ballore[1] in his paper on the 'Seismic Phenomena in British India and their connection with its Geology' has drawn attention to the fact that the Andamans and the neighbouring islands are resting on a long and narrow submerged ledge on either side of which there are abysses deeper than 5,000 feet. The geological features of the Islands are akin to those of the Arakan region, and it is thus inferred that the area had subsided in a not very remote epoch, leaving the Andaman group of Islands as the last traces of the land. From a study of the vegetation on the Andaman Islands Kurz and subsequently Oldham[2] had also concluded that the region has been gradually sinking. Oldham, however, further observed that the evidence of the raised beaches along the coast of the Islands irresistibly pointed to elevation also having taken place in some parts of the area. Gee[3] also recorded evidence of recent uplift in the coral boulders and recent shells in the vicinity of Freshwater Bay and in the cliff of limestone at Hut Bay, Little Andaman Island. It is, thus conclusively proved that both elevation and subsidence have been going on in this region. A condition of considerable instability, therefore exists and the 1941 earthquake represents only an effort of nature to establish restive adjustment.

[1] Ballore, M. De., *Mem. G S. I.*, Vol. XXXV (1911), pp. 177 and 179.

[2] Oldham, R. D., *Rec. G. S. I.*, Vol. XVIII (1885), pp. 143-145

[3] Gee, E. R., *Rec. G. S. I.*, Vol. LIX (1926), p. 221

PRELIMINARY NOTES ON THE GNEISSIC COMPLEX OF NONGMAWEIT-RAMBRAI-NONGSTOIN PLATEAU, KHASI HILLS, ASSAM.

BY A. M. N. GHOSH, B.SC. (HONS.), A.R.C.S., *Superintending Geologist, Geological Survey of India.*

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INTRODUCTION

The object of this paper is to bring to notice some of the varied rock-types of the gneissic complex of the western and the north-western portions of the Khasi Hills which remained unsurveyed until recently. An attempt has been made to enumerate the different types and to group them in order of their relative antiquity. The area forms part of the Assam plateau and has an average elevation of about 3,500 feet. It falls within the parallels of latitude 25° 30′ and 25° 45′ and longitude 91° 0′ and 91° 22′, and includes the villages of Nongmaweit (25° 40′:91° 04′), Rambrai (25° 39′:91° 19′) and Nongstoin (25° 31′:91° 16′) on its north, east and south respectively. Although in the past some parts of the area had been visited by several officers of the Geological Survey of India, no published account of the geology is available. It was not until 1929 that an account of the geology of a few square miles in the neighbourhood of Nongmaweit was published by J. A. Dunn.[1] The present paper summarises the results of the writer's observations over a larger area, some 250 square miles, during the field-season 1938-39.

Structural features of the Assam plateau

The Khasi Hills occupy the heart of the central upland of Assam which has the Garo Hills on its west and the Jaintia Hills on its east, and forms a water-shed to the Surma and the Brahmaputra valleys on its south and north respectively. The Assam plateau may be regarded as a fragment of Peninsular India trapped between the Himalayan and the Burmese elevations. Its southern side rises abruptly from the Sylhet-

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[1] *Mem. Geol. Surv. Ind.*, LII, part 2, p. 168, (1929).

Mymensingh plains forming steep scarps of Cretaceous and Eocene beds as a result of faulting. The fault is of the nature of an overthrust in the Garo Hills, a broken monocline in the Khasi Hills and a normal tensional fault in the Jaintia Hills, along a zone of weakness. The northern side, overlooking the Kamrup plains, however, presents no such faulted appearance although it faced the orogenic stresses during the upheaval of the Himalaya. On this side the plateau consists of Archaean gneisses and granites, and apparently remained stable since Pre-Cambrian times.

The basis of the tableland in the area under review is provided by a complex of para- and ortho-gneisses intimately mixed up and folded. The oldest rocks are a group of ancient sediments which were intruded by basic and acid igneous rocks and were metamorphosed under deep-seated conditions. They were subjected to further intrusions of granites some of which were rendered gneissose and flow-banded. A classified list of the chief petrological types is given below :—

- Gneissic Complex.
  - Unfoliated Intrusives.
    - Pegmatites and quartz veins.
    - Massive, porphyritic and coarsely crystalline biotite-granites carrying basic segregation and inclusions of gabbro, norite and picrite.
  - Younger Ortho-gneisses.
    - Coarse and fine-gained granite-gneisses.
  - Older gneisses.
    - *Ortho-gneisses*
      - Acid :
        - Aplites, granulose, streaky and gneissose.
      - *Basic* :
        - Hornblende and tremoliteschists ; amphibolites pyroxene-hornblende granulites.
    - *Para-gneisses.*
      - Biotite and hornblendebiotite gneisses (partly igneous) ; biotite-cordierite-gneisses ; felspathic biotite-granulites ; diopside-felt per-granulites ; garnet-granulite ; biotite-cordierite-sillimanite granulites with quartz and with or without felspar ; sapphirine-cordierite-rock with green spinol sillimanite-quartz-schist ; sillimanite-corundum rock ; garnet-sillimanite-quartz rock ; quartz-magnetite rock sometimes with amphibole.

Biotite-gneiss and its variants

The most widely distributed member of the older gneisses is a finely banded *biotite-gneiss* often showing granulose texture. The gneiss is fine-grained and light grey to whitish in colour and composed of quartz, tiny flakes of pale and brownish green biotite, and felspar, which may be either microcline or oligoclase or both in varying proportions. Bands of *quartz-magnetite rock, calc-granulite, tremolite-* and *hornblende-schists* are present in the gneisses of the northern area. Sometimes hornblende is in excess of biotite and the rock becomes a *hornblende-biotite-gneiss.* Very often felspar is lacking resulting in *quartz-biotite-gneiss.* On the central and the southern sides of the plateau cordierite and sillimanite appear and give rise to *biotite-cordierite-gneiss.* The biotite-gneiss is highly puckered, crumpled and contorted at places and has been subjected to *lit-par-lit* injection by a fine-grained aplitic granite. No single mode of origin can be ascribed to the formation of the biotite-gneiss on account of the diversity of its composition. At one place it may be a composite-gneiss formed by the granitisation of biotite and hornblende-schists, remnants of which are present at many places: in another it may represent an impure metamorphosed grit in which the original clastic characters have disappeared.

Felspathic biotite-granulites

On the plateau the biotite-gneiss is frequently associated with a peculiar, dense, compact, dark coloured and extremely fine-textured felspathic granulite which has a greasy appearance and breaks with a semi-conchoidal fracture like quartzite. The exposures are well-jointed and in some of the gorges form sheer cliffs as of quartzite. Biotite is the chief ferro-magnesian mineral and the rock may well be termed a *biotite-granulite.* There are types in which the biotite may be totally or partially replaced by hornblende, forming *hornblende-granulite* or by colourless diopside occurring either as grains or as sieve-textured plates as in *diopside-granulite.* Some varieties contain pink garnet, usually sieve-textured, and the rock is then *garnet-granulite.* As was the case with the biotite-gneiss, with which there is a similarity in composition, the biotite-granulite has been rendered gneissose at many places by the *lit-par-lit* injection of fine-grained aplitic granites.

Cordierite-biotite-granulites.

There is another variety of the granulite containing cordierite as the principal mineral. Sometimes the cordierite may occur with biotite and quartz only or it may be associated with the felspars, oligoclase and microcline. In the felspathic type microcline is the last to crystallise and it occurs within the interstices of the xenoblasts of cordierite. Biotite occurs either enclosed in a xenoblast of cordierite or winds round porphyroblasts of cordierite. Sillimanite is an important accessory of cordierite-biotite-granulite and may be found intergrown with biotite or radiating out from biotite. Sometimes sillimanite is enclosed by biotite. Other accessories are zircon, occasional garnet, rutile, magnetite and green spinel.

Sillimanite-quartz-schist.

Prominent amongst the less important members of the older gneisses is *sillimanite-quartz-schist* which occurs as lenticular bands within the cordierite-bearing gneisses and granulites. At places sillimanite occurs either alone or in association with corundum and segregates in sufficient quantity so as to give rise to workable deposits of the mineral.

Other less important types.

Of the other unimportant types the noteworthy varieties are a finely banded and highly folded and crumpled *quartz-magnetite-rock*, sometimes carrying a light brown amphibole and little apatite; *calc-granulite* composed of diopside, hornblende and basic plagioclase together with some quartz, occasional sphene, epidote, garnet and rare scapolite ; and *sapphirine-cordierite-rock* with green spinel forming narrow bands in the para-gneisses of the central area. Sapphirine occurs in granules as well as in clusters enclosing green spinel from which the former mineral seems to have grown. Generally sapphirine is set in a mosaic of porphyroblasts of cordierite which is the last mineral to crystallise. Sapphirine also occurs in association with a very pale green micaceous mineral showing a lemon yellow pleochroic halo characteristic of cordierite and is also found with an orthorhombic amphibole belonging to the anthophyllite-gedrite group.

Basic bands: pyroxene and pyroxene-hornblende-granulites.

There are numerous bands of basic rocks the texture of which is either granulose or gneissose. These bands have been intimately folded with the gneisses and help to give an idea of the complexity of the folds. The basic rocks are of the nature of sills and dykes showing a certain amount of variation in composition. Some types are rich in pyroxene, while others are rich in hornblende. The principal felspar is water-clear and fresh andesine with subordinate oligoclase and labradorite. Accessory constituents are usually magnetite, a little reactional biotite, interstitial quartz and occasionally apatite and garnet. The principal pyroxene in these rocks is hypersthene of the usual type or its colourless variety, both showing straight as well as inclined extinction. Hypersthene is often intergrown with an iron-rich diopside. Hornblende is olive-green and brownish-green and has formed by the amphibolisation of the pyroxenes.

In some of the pyroxene-hornblende-granulites there is a suggestion of the formation of hypersthene from the iron-rich diopside. Usually the former is intergrown with the latter and the two form clusters indicating one to have grown from the other. In such cases the bulk of the pyroxene is a light green diopside with little patches of hypersthene. In the complex process of the amphibolisation of the diopside, all the calcium would be used up in the formation of hornblende, liberating some iron and quartz and a little magnesia. It is easy to visualise that a combination of the ingredients in the right proportion would give rise to hypersthene.

Aplites.

The older gneisses of the plateau were subjected to granite intrusions in several phases and on a batholythic scale. The earliest phase of the granite intrusions seems to have been a very leucocratic aplitic type consisting essentially of quartz and microcline felspar. Some varieties contain oligoclase and subordinate microcline or orthoclase, largely microperthite. In many instances microperthite encloses round grains of quartz arranged in a row. Quartz is also intergrown with felspar, giving rise to myrmekitic or granophyric texture. Sometimes the larger grains of quartz show a sutured outline and the jagged periphery is surrounded by smaller grains of the same mineral or felspar. When ferromagnesian minerals occur, the chief is a dark brown biotite, often showing pleochroic halo. Ranking next in importance is hypersthene, sometimes showing inclined extinction. Hypersthene occurs either alone or intergrown with a light green pyroxene. In hand specimens as well as under the microscope, the texture is either granulose or streaky the streakiness being due to linear but discontinuous arrangement of either biotite or magnetite.

Younger granites.

The aplites were followed by intrusions of coarsely crystalline biotite-granites, which can be texturally divided into (*a*) foliated and gneissic types, (*b*) unfoliated but flow-banded types resulting from the linear arrangement of the phenocrysts of felspar, and (*c*) coarsely crystalline massive varieties showing no banding whatsoever. Similar granites have been noted elsewhere in Peninsular India, in Bihar, Orissa, M. P. and Bundelkhand. Where the gneissic and the flow-banded varieties occur together, the latter usually forms bosses within the gneissic-granites. There is a rough parallelism between the direction of the foliation of the granite-gneiss and of the alignment of the felspar-phenocrysts of the flow-banded granites, which is mostly E.-W. While the gneissic banding in the granites seems to be due to directional pressure acting on a semi-plastic mass, the flow-banding indicates movement of magma in a direction at right angles to the direction of stress. Flow-banding also indicates prolonged cooling of the granite melt permitting the growth of larger crystals prior to the movements that caused gneissic banding in the nearly consolidated granites of the peripheral regions.

The unfoliated granites carry inclusions of the country rock and are also characterised by the usual basic segregations. One of the granite bosses was found to carry large bodies of olivine-gabbro, norite and picrite as inclusions. The pyroxenes of the olivine-gabbro are pale green to nearly colourless augite, a little schillerised and feebly pleochroic hypersthene and some diallage. Hypersthene in norite and picrite is strongly pleochroic and sometimes shows inclined extinction. Olivine is usually fresh and happens to be the earliest mineral to crystallise. Although the basic inclusions may be regarded by some as the products of assimilation by granites of the older sediments rich in lime, iron and magnesia, I have regarded them in the absence of field-evidence, as basic differentiates of an ur-magma.

All the older rocks are much traversed by pegmatite and quartz veins which complete the cycle of granite intrusions. The pegmatite veins sometimes carry small flakes of muscovite and sporadic crystals of tourmaline, and travel both along as well as across the foliation of the gneisses.

The gneisses and the granites are traversed by basalt sills and dolerite dykes. They have not been metamorphosed and are presumably of the same age as the Sylhet trap (?Jurassic).

Concluding Remarks.

The textural peculiarities of the granulites and the granulose-gneisses of the area and the occurrence of such anti-stress minerals as hypersthene, cordierite, sillimanite, spinel, etc., point to conditions of great heat and uniform pressure to which the older rocks were subjected at some period of their history. From the presence of cordierite and spinel it appears that directional stress did not at any stage reach a maximum, while sillimanite is an indication of the high temperature that plays an important role in deep seated metamorphism. Leaving aside the biotite-gneisses, a portion of which may represent finely foliated granites, a general consideration of the mineral assemblage of those rocks containing sillimanite, cordierite, quartz, etc., leads to the conclusion that both pelitic and psammo-pelitic sediments were involved in plutonic metamorphism. As can readily be understood, the sediments were rich in alumina and magnesia, the proportion varying from place to place. Allowing for the modifications produced by the later injections of granites, one can speculate that those which were highly aluminous gave rise to the corundum-sillimanite suite of rocks, whilst sediments which had magnesia in addition were responsible for the cordierite-bearing rocks. There were, perhaps, minor bands of a calcareous nature which were metamorphosed into calc-granulites. On the other hand sediments containing a high percentage of magnesia were metamorphosed into the somewhat rare but interesting types characterised by sapphirine, spinel, cordierite and anthophyllite.

The ancient basic intrusives, which are so intimately associated with the para-gneisses, are represented by the numerous bands of pyroxene-hornblende-granulites and allied rocks having undergone the same metamorphic processes. The early granites were converted at the same time into granulose aplites. Much of the basement complex has been stoped away by intrusions of later granites, which have been rendered gneissose over a very large area and they form the 'granitoid gneisses' so common all over the Assam plateau.

ON THE JUNCTION OF THE SHILLONG SERIES AND THE GRANITE-GNEISS ON THE MAIRANG-LYNGKHOI PLATEAU, W. S. W. OF SHILLONG, KHASI HILLS, ASSAM. BY A. M. N. GHOSH, B.SC. (HONS.), A.R.C.S., *Superintending Geologist, Geological Survey of India.*

During his investigation of the geological formations of the Shillong plateau, Medlicott came across a series of metamorphosed sediments of "schistose clay-slates and granular quartzites" which he named as the Shillong series. He also noticed "granitoid gneiss of the older metamorphics" lying to the north-west of the exposures of the Shillong series. Although he recognised that "there is a very wide difference between the gneiss and the Shillong series" he was unable to say "with what precision the boundary between the two could be laid down".[1] Medlicott found some granites within the Shillong series and according to him "the true granite so largely associated with the Shillong series never makes any approach to this structure" referring to the "granitoid gneiss of the older metamorphics".[1]

The junction of the Shillong series and the granite-gneiss (Medlicott's granitoid gneiss) was studied by the present writer at several places on the Mairang plateau during the field-season 1938-39. The boundary between the Shillong series and the granite-gneiss is fairly sharp and well-defined. On the eastern side of the plateau the boundary runs roughly N.E.-S.W. and it changes to E.N.E.-W.S.W. on the southern side of the plateau. In this area the Shillong series consists of quartzite, quartz-biotite-schist, quartz-sericite-schist, phyllite and slate all of which have the same general strike as the boundary and have high south-easterly and southerly dips. Near the village of Lyngkhoi (25°30′:91°37′) the Shillong series tapers into an insignificant band of coarse-grained and saccharoidal quartzite, sandwiched between an unfoliated, coarsely crystalline granite on its south-east and the gneissic granite of the Mairang plateau on its north-west. The quartzite is well-bedded and jointed and forms sheer cliffs.

Wherever the granite-gneiss and the quartzite occur in juxtaposition, the direction of the foliation of the former runs almost parallel to the main set of vertical as well as highly inclined joints of the latter. This direction lies between N. 20° E.-S. 20° W. and E.N.E.-W.S.W. Away from the Shillong quartzites, the foliation of the gneiss lies between N. 40° E. and E. 10° N. At a few places the quartzite is sericitic near the base where it occasionally carries flattened and elliptical pebbles of vein quartz set in a schistose and micaceous matrix and presenting the appearance of a conglomerate. The quartz veins appear to be of granitic origin. The flattening and the rolling of the pebbles appear to have been caused by differential movements at the contact of the granite-gneiss and the Shillong quartzite.

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[1] *Mem. Geol. Surv. Ind.*, VII, p. 196, (1869).

On the summit of a ridge near Lyngkhoi, narrow bands of shattered quartzite were noticed along the foliation of the granite-gneiss. Similar bands of quartzite varying from 4 inches to 10 inches in thickness occur along the different folia of the gneiss in the nala immediately north-east of Lyngkhoi, where in the river bed a wedge of a fine-grained, light grey granite-gneiss was found along the bedding of the quartzite.

A few miles to the north-east of the above area the rocks consist of the argillaceous facies of the Shillong series. Here the granite-gneiss is in juxtaposition with quartz-biotite-schist. As one proceeds in a south-easterly direction, away from the granite-gneiss, the quartz-biotite-schist is replaced by quartz-sericite-schist and sericitic quartzite. Further south-east appear phyllites with flaggy intercalations followed by slates. Near the border of the granite-gneiss narrow tongues of granite are present along the cleavage planes of the quartz-sericite-schist.

The above features taken together suggest an intrusive relationship of the granite-gneiss to the Shillong series. The quartz-sericite-and quartz-biotite-schists were no doubt formed as a result of dynamo-thermal metamorphism induced by granite intrusions on the argillaceous rocks, phyllites, etc., of the Shillong series. The pseudo-conglomerates mentioned above were formed by later movements which took place after the consolidation of the granites.

ON THE SYSTEMATIC POSITION OF *Alveolina meandrina* CARTER, TOGETHER WITH A DISCUSSION ON THE AGE OF THE ROCKS IN WHICH THIS FOSSIL HAS BEEN FOUND.*

BY Y. NAGAPPA, *Palaeontologist, Burmah Oil Co. (India Concessions) Ltd.* (With plates 8 to 10.)

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INTRODUCTION

During the period 1852 to 1861[1] Carter described a number of foraminifera from Sind and Baluchistan. Among the fossils described was also a collection by Dr. Cook[2] from the 'Valley of Kelat' (Kalat). Carter mentions two 'fossil deposits' in this collection,[3] the assemblages are :—

(*a*) Deposits with larger fossils—
Nummulites exponens.
Assilina obesa.
Nummulites perforata.
Conulites cooki.
Alveolina elliptica.

(*b*) Deposits with diminutive foraminifera—
Orbitoides dispansa (stellate variety).
Alveolina elliptica (small variety).
Operculina.
Orbitolina.

Of these, assemblage (*a*) seems to belong to the Khirthar but assemblage (*b*) appears to contain a mixed fauna of Ranikot-Laki affinities.

Although some of the generic names as employed by Carter have been revised as a result of re-study of the original material, there is one form, *Alveolina meandrina*, which appears to have escaped the scrutiny of both geologists and palaeontologists. This is partly because the form is less common, and even when present, it does not seem to occur in profusion. Carter[1] described this form as follows:—

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[1] *Ann. Mag. Nat. Hist.* Ser. 2, Vols. 10 and 11 ; Ser. 3, Vol. 8.

[2] Then Medical Officer to the British Agency at Kalat.

[3] *Op. cit.*, Ser. 3, Vol. 8, p. 172.

> "Elliptical, nearly globular, externally covered with whorls of tortuous septal lines and interspaces, indicating the form of the chambers beneath; internally composed of a spiral layer of long, narrow, tortuous chambers commencing from a central cell and gradually elongating themselves in each direction, at right angles to the spire, as the latter winds round its long axis to form the test, each chamber extending from pole to pole, and each layer covered with a cortical tubular reticulation.
>
> Largest size: Length 11/48 in.; thickness 10/48 in.
>
> Locality: Valley of Kelat (Dr. Cook).
>
> Associates: Found in the bed of diminutive foraminifera mentioned under the head of *N. kelatensis.*"

From Carter's illustrations,[2] though not quite so manifestly from his description, it is clear that this form is not a true alveoline (*vide* Pl. 8, Figure 1, reproduced from Carter). Carter himself seems to have been in doubt about the generic placing of this species. Referring to this form earlier,[3] he writes:—

> "while the new species, which I have described further on, under the name of *A. meandrina,* is again so different from either and from any other existing description, that at first sight it seems doubtful whether it should not form the type of a new genus."

He, however, preferred to keep this species in the genus *Alveolina,* for he writes further:—

> "On examining it internally, however, it is found that its chambers, although tortuous like those on the surface of *N. gyzehensis,* etc., commence in a spiral form as simply as those of *Operculina,* but instead of remaining subsigmoid, as in *A. elliptica,* become tortuous, while there is a reticulated canal-structure arching over each, and supported on vertical tubes connected with a similar structure over the preceding layer, which, when viewed

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[1] *Ibid.,* p. 381.

[2] *Ibid.,* Pl. 17, fig. 4.

[3] *Ibid.,* p. 328.

> longitudinally in a vertical or horizontal section, appears to correspond to the tubular structure arching over the chambers and interseptal canals respectively of *A. elliptica,* which structure, again, corresponds. as before stated, to the spicular cord and interseptal canals of *Operculina and Nummulites.*"

The description given by Carter is by no means clear and may even be misleading. Nevertheless, it is obvious that he is describing a form not far different from a nummulite.

Foraminifera similar to Carter's *Alveolina meandrina* have lately been found in beds of Eocene age in W. Pakistan[1],[2] and Assam.[3] A detailed study of these forms by F. E. Eames and the author has shown that there is little reason to doubt their identity with Carter's species[4] and that the form in question answers more to the description of *Miscellanea* Pfender than to *Alveolina* d'Orb. A comparison of the specimens illustrated in Plates 7 and 9 with Carter's illustrations will make the above point clear.

A fuller description of this form is given below.

DESCRIPTION OF SPECIES

MISCELLANEA Pfender[5] 1934.

Miscellanea meandrina (Carter) 1861.

(Pl. 8, figs. 1, 2 ; Pl. 9 & Pl. 10, figs. 1, 2.)

Alveolina meandrina Carter 1861. Ann. Mag. Nat. Hist. Ser. 3, Vol. 8, p. 381 ; Pl. 17, fig. 4.

DIAGNOSIS:

The microspheric and the megalospheric forms have slightly different morphological characters and it might be useful to describe them separately. Carter's description and illustrations seem to refer only to the microspheric form.

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[1] Tarkhobi (Kohat district), 38 0/14, 33° 35½′:71° 49¾′.

[2] Khairabad (Punjab Salt Range), 38 P/9, 32° 53′:71° 36′.

[3] Narpuh (Khasi and Jaintia hills), 83 C/8, 25° 10′:92° 23′.

[4] Carter's types are deposited in the British Museum (Natural History) ; they bear Reg. Nos. P. 30038—50. I am indebted to Mr. C. D. Ovey for this information. Mr. Eames has kindly checked up these specimens and confirms that they are *Miscellanea* and therefore be called *Miscellanea meandrina* (Carter).

[5] *Bull. Soc. Geol.,* Fr. (5) Vol. 4, pp. 225-236.

Microspheric form:

Test elliptical or very nearly spherical; surface smooth or feebly granular. The septal filaments are typically meandriform. In equatorial sections there are 10-15 whorls; the whorls are closely spaced, chambers are small, broader than high, septa short, thick and oblique. The whorl walls clearly show the typical broken or "degenerated" character which is considered an important diagnostic character of *Miscellanea.* In meridian section, a tendency towards the development of pillars is noticed, but these pillars are confined to the early stage and appear as "buried pillars". Since the form is very nearly spherical it is not easy to prepare properly oriented sections.

Megalospheric form:

Test strongly biconvex with rather sharp periphery. Septal filaments are of the simple-radiate type but are strongly gyrate and meet the periphery almost tangentially. Surface smooth; in less weathered specimens there is an indication of the presence of one or two granules near the pole. In equatorial sections there are 4-5 whorls, the megalosphere is usually double, the primordial chamber being nearly circular in section, while the second chamber is shorter in one dimension and is almost semicircular. Chambers in the equatorial layer are slightly larger than those of the microspheric form and septa are strongly oblique and curved. In meridian section there is again an indication of the tendency towards the development of an occasional pillar. The marginal cord as developed in *Nummulites, Assilina,* and *Operculina* is apparently not present here and in this respect also the species shares the character exhibited by *Miscellanea.* Here again, the "degenerated" wall structure of the test is very well seen.

Many specimens are not available for study and it is not therefore possible to estimate the limits of variation of this species. From the few that were measured it has been found that the ratio diameter/thickness of the test shows variation within very narrow limits as can be seen from the table below:—

—	Microspheric.				Megalospheric.				
	Salt Range.			Kohat.	Salt Range.			Kohat.	
Diameter of test (in mm.)	5.2	5.7	4.6	5.5	3.3	3.0	2.8	2.2	2.1
Thickness of test (in mm.)	3.8	4.0	3.7	4.0	2.3	2.2	2.1	1.6	1.7
Dia./Thickness . .	1.37	1.42	1.25	1.37	1.3	1.36	1.3	1.37	1.23

Only one equatorial section of the microspheric form (Kohat dt.) shows the coiling in the central part clear enough for measuring; the results are shown below:—

Whorl No.	Dia. in mm.	No. of chambers
1	0·16	6
2	0·37	11—12
3	0·8	14—15
4	1·23	17—18
5	1·66	20—21
6	2·04	Not clear.
7	2·32	
8	2·61	
9	2·8	
10	3·0	

Corresponding data for two sections of the megalospheric form are:—

Whorl No.	Dia. in mm.		No. of chambers.	
——	Salt Range	Kohat.	Salt Range	Kohat.
1	1·03	0·83	8	9
2	1·69	1·24	17	15—16
3	2·32	1·72	19	17—18
4	2·73	2·08	21	1

The primordial chamber measures 0·2×0·24 sq. mm. (Kohat) and 0·2 mm. in diameter (Salt Range).

DISTRIBUTION:

(*a*) "Valley of Kelat" (Kalat), Cook's collection (34 K/12, 29°0′:66°48′).

(*b*) Khairabad Limestone, near Khairabad, Punjab Salt Range.[1] (38 P/9, 32° 53′:71° 36′).

(*c*) Brecciated Limestones and Shales overlying the massive algal and foraminiferal limestones—the lowest beds exposed—near Tarkhobi, Kohat district, (38 0/14, 33°35½′:71°49¾′).

(*d*) Lower part of the Sylhet Limestone near Narpuh in the Khasi and Jaintia hills, S. E. of Shillong (83 C/8, 25°10′:92°23′), Assam.

EVIDENCE OF AGE

In the last three areas mentioned above, the strata in which *Miscellanea meandrina* occurs consist mainly of bedded, or massive, highly foraminiferal limestones which have yielded a remarkably consistent assemblage of fossils in spite of the wide separation of the two localities in W. Pakistan from that in Assam. The evidence relating to the age of these rocks in these localities is discussed below.

(i) Khairabad Limestone, Salt Range.

As a result of detailed mapping in this area E. R. Gee[2] tentatively regarded the Khairabad Limestone as of Ranikot age and this opinion was also shared by the other geologists[3] who examined the area with him. Subsequently, from a study of the fossils collected from the Eocene rocks of the Punjab Salt Range, E. S. Pinfold and L. M. Davies[4] have confirmed this view. Davies correlated the Khairabad Limestone with the "highest Ranikot levels of Sind as described by Vredenburg"[5] and therefore it is obvious that the Khairabad Limestone is of Upper Ranikot age.

(ii) Brecciated Limestones and Shales, Kohat.

Although Davies has carried out a detailed examination of the Eocene rocks exposed in several localities in the Kohat district, he apparently had no opportunity to visit the Panoba area. Of the several geologists who have contributed to our knowledge of the geology of this area, *viz.*: Wynne,[6] Griesbach,[7]

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[1] Specimens presented by W. D. Gill formerly of the Attock Oil Co., Ltd.

[2] *Rec. Geol. Surv. Ind.*, LXIX, part 1, p. 65.

[3] E. S. Pinfold and P. Evans, *ibid.*, pp. 64, 65.

[4] *Pal. Ind.*, N. S., XXIV, Mem. 1, p. 4.

[5] *Ibid.*, pp. 15-16.

[6] *Rec. Geol. Surv. Ind.*, XII, part 2, pp. 100-114.

[7] *Op. cit.*, XXV, pp. 102-107.

Parsons,[1] Pascoe,[2] Pinfold,[3] Gee,[4] and Evans,[5] only the last three have stated, although basing part of their conclusions on lithological grounds, that the lowest beds in the Tarkhobi-Panoba anticline are of Ranikot age. They correlated these beds with the Khairabad Limestone of the Salt Range and other Upper Ranikot beds in the Kohat district. Typical Ranikot foraminifera have subsequently been found in these beds.

(iii) **Sylhet Limestone, Assam.**

It has been known that the bulk of the Sylhet Limestone of Assam is of Khirthar age.[6] The presence of beds of Ranikot age in this area has been suspected on stratigraphical grounds, but such beds[7] have been shown to occur below the Sylhet Limestone. A. M. N. Ghosh[8] assigns an Upper Laki or Lower Khirthar age to the upper part and a Laki age to the middle portion of the Sylhet Limestone, but states that " the age of the lowest band of foraminiferal limestone remains undetermined ".

Lately W. E. Fraser, K. L. Bhola, W. B. Metre and A. B. Das Gupta[9] carried out a detailed examination of the Eocene succession in this area. Their observations together with the palaeontological evidence from the samples collected by them have proved the presence of rocks of Upper Ranikot age in the lowest beds of the Sylhet Limestone.[10] The following fossils, identified by Eames and the author, occur in the lowest beds of the Sylhet Limestone:—

Lockhartia haimei (Davies).
Miscellanea miscella (d'Arch. & Haime.).
Miscellanea stampi (Davies).
Miscellanea meandrina (Carter).
Orbitosyphon tibetica (Douvillé).
Alveolina ? n. sp.
Corallina grandis (Das Gupta).
Distichoplax biserialis (Dietrich).

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[1] *Jour. Inst. Pet. Tech.*, Vol. 12, No. 58, pp. 439-506.

[2] *Mem. Geol. Surv. Ind.*, XL, p. 410.

[3] *Rec. Geol. Surv. Ind.*, XLIX, Part 3.

[4,5] *Op. cit.*, LXIX, pp. 65, 70-71.

[6] P. Evans, *Trans. Min. Geol. Met. Inst. Ind.*, Vol. 27 (1932), pp. 175-6. Evans draws attention to the possibility of the Laki age for the lower part of the Sylhet Limestone.

[7] The equivalent of Cherra Sandstone. A. M. N. Ghosh, *Rec. Geol. Surv. Ind.*, LXXV, Prof. Paper 4, pp. 17-18 (1940).

[8] *Ibid.*, p. 17.

[9] Of the Burmah Oil Co. (India Concessions) Ltd.

[10] *Miscellanea meandrina* is confined to these lowest beds.

(iv) Cook's material from the "Valley of Kelat" (Kalat).

Other fossils cited by Carter as "associates" of his *Alveolina meandrina* do not seem to give much evidence of age. It may however be pointed out that Davies,[1] in re-describing and figuring *Nummulites kelatensis* Carter, considers that the horizon of this fossil may be Laki. In view of the fact that, in the three localities referred to above, *Miscellanea meandrina* occurs in beds of Upper Ranikot age, it is not improbable that part of Cook's collection came from beds of the same age.

ACKNOWLEDGMENT

The author is indebted to Dr. M. R. Sahni of the Geological Survey of India, and to Messrs. P. Evans and A. J. Philipson of the Burmah Oil Co., for helpful suggestions during the preparation of this paper.

EXPLANATION OF PLATES.

PLATE 8. *Miscellanea meandrina* (Carter).

FIG. 1 a-c. Original figures reproduced from Carter (Pl. 17, fig. 4 a-c) enlarged twice. No magnifications are given by Carter. (*a*) To show the meandriform septal filaments, (*b*) to show the equatorial section and (*c*) lateral section showing septal filaments below the surface.

FIG. 2 a-d. Specimens from the Khairabad Limestone, Salt Range. (*a*) Surface view of microspheric form showing arrangement of septal filaments, (*b*) meridian section of microspheric form showing buried pillars in the early stage, (*c*) meridian section of megalospheric form and (*d*) equatorial section of megalospheric from *a*. × 4 (G. S. I. No. 17456) ; *b*. × 13 (No. 17457) ; *c*. × 18 (No. 17458) ; *d*. × 15 (No. 17459).

PLATE 9. *Miscellanea meandrina* (Carter).

Equatorial section of one of the syntypes from the material described by Carter × 10 ; Brit. Mus. (N.H.) P. 30047. By courtesy Brit. Mus. (N.H.).

PLATE 10. *Miscellanea meandrina* (Carter).

FIG. 1 a-c. Specimens from the Ranikot Limestone, Tarkhobi. (*a*) Lateral section of the microspheric form showing arrangement of the septal filaments, (*b*) equatorial section of the megalospheric form and (*c*) equatorial section of the microspheric form. *a*. × 15 (G. S. I. No. 17460) ; *b*. × 23 (No. 17461) ; *c*. × 15 (No. 17462).

FIG. 2 a-b. Specimens from the lower part of the Sylhet Limestone. (*a*) and (*b*) skew sections in rock slides. *a*. × 15 (G. S. I. No. 17463) ; *b*. ×13 (No. 17464).

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[1] *Quart. Journ. Geol. Soc.*, London, XCVI, Part 2, p. 210.

A PRELIMINARY NOTE ON *Pseudocycadeoidea*, A NEW GENUS OF PLANT FOSSILS FROM THE TRICHINOPOLY DISTRICT, MADRAS.*

BY N. K. N. AIYENGAR, M.A., F.G.S., *Geologist*, AND K. JACOB, D.SC., F.G.S., F.N.I., *Palaeontologist, Geological Survey of India.*

(With Plates 11 to 13.)

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INTRODUCTION

The specimen described in this paper was collected by Dr. M. S. Krishnan, then Superintending Geologist, Geological Survey of India, and one of us during the field season 1939-40 in the bed of a stream about three furlongs north-west of Varagur (11°15′:72°30′; Varaghoor of H. F. Blanford), a village 8 miles N. N.-W. of Ariyalur in the Trichinopoly district, South India (*see* Map on page 328, *Fossil wood*).

In this preliminary account the external features and habit of the fossil are briefly described and, as far as permissible, compared with those of some known species of *Cycadeoidea* with which the Indian specimen shows the closest external resemblance. It does not appear from the one or two sections prepared that the internal features of the specimen are well preserved. Owing to various difficulties it has not been possible to get more sections of the shoot made. The details of the internal structure, if seen preserved at all, will be described in a subsequent paper. It may be argued that the discussion on the affinities of the specimen with the species previously described may well be reserved until the internal structures are fully investigated. But fuller discussion will of course follow if fresh details are known.

The discovery of this specimen in the Trichinopoly beds is important as it forms the first record of a fossil which shows

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* Received for publication in November 1941.

the closest resemblance with the genus *Cycadeoidea*[1]. The reasons for referring the specimen to a new genus are discussed elsewhere in this paper.

Abundant material of *Cycadeoidea* has been known from North America and Europe, and a few specimens from Japan. From North America alone more than a thousand specimens have been reported. The southernmost limit of the genus is known to be New Mexico (U. S. A.)[2],[3].

Mention should be made here of the reported occurrence of cycadean wood from the Cretaceous rocks of the Trichinopoly area by Blanford[4] and some of the later workers[5]. The generic identity of these specimens is unknown. While the possibility of their identity with cycadeoideans cannot be overlooked, it is possible that they were trunks of a different type.

So far the geographical distribution of *Cycadeoidea* has been known to be in isolated patches on the face of the globe; and wherever the trunks have been known to occur, they have been found usually in fair abundance. This is true at least of North American, English and Italian localities.

A very brief account of the geological features of the Trichinopoly area, we believe, will not be out of place. The Cretaceous rocks near Trichinopoly form one of the well known geological formations in India on account of its wealth of marine fossil fauna. The rocks extend from Kanakilliyanallur (10°59′30″: 78°53′) in the south to the Vellar river in the north in a N.E.-S.W. direction for a distance of about 35 miles, and rest unconformably on the Archaean gneisses and charnockites with the intervention of small patches of Upper Gondwanas in a few places. Based on the lithological and palaeontological differences the whole formation has been sub-divided into four stages, namely, the Uttattur, Trichinopoly, Ariyalur and Niniyur stages, mentioned in the order of deposition. In the two lower stages " cycadaceous wood ", generically unknown, are reported to occur. Fragments of other ill-preserved exogenous fossil wood as well as abundant remains of marine animals are also found in all the stages. The accompanying table which is a modification of Cotter's[1] table of stages of the Cretaceous of South India, gives the sub-divisions and their European equivalents, of the Cretaceous rocks of the Trichinopoly district.

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[1] In the following account the term "cycadeoidean" should be taken to mean the genus *Cycadeoidea* as distinct from those included in the Williamsoniae tribe. The Cycadeoideae and Williamsoniae are together referred to as "cycadeoids".

[2] Seward (33, p. 343) mentions that the genus is also found in the Mesozoic of Mexico.

[3] Madigan (44, p. 138), however records the occurrence of silicified stems of "cycads" and palms from the Cretaceous gravel beds of the Lake Eyre area in Australia. I was not able to trace these specimens during my recent visit to Australia. It is therefore not possible to say whether any of these "cycads" belongs to the genus *Cycadeoidea*—*K. J.*

[4] Blanford (65), pp. 49, 79, 111, 112.

[5] Sahni (22), p. clxvii, 7.

Table showing the sub-divisions of the Cretaceous rocks of the Trichinopoly district.

(Adapted from Cotter(38), Table on p. 48.)

Stage		Age	
4. Niniyur	b. Niniyur Beds (whitish sandy limestone). *Hercoglossa danica, Lyria formosa, Stylina parvula*, etc.	Danian.	
	a. Sands without fossils.		
3. Ariyalur	Ariyalur Beds (pale coloured sands and clays) *Desmoceras sugata, Brahmaites brahma, B. vishnu, Parapachydiscus egertonianus, Hauericeras gardeni, Kossmaticeras, Baculites vagina. Alectryonia ungulata, Trigonoarca galdrina, Macrodon japeticum*, etc.	Maestrichtian to Campanian	Upper. Senonian.
2. Trichinopoly	c. Clays with *Gaudryceras varagurense, Bostrychoceras indicum, Puzosia gaudama, Desmoceras sugata, Placenticeras tamulicum, Kossmaticeras marsupites.*	Santonian.	Lower Senonian.
	b. Yellow and glauconitic clays with *Peroniceras dravidicum.*	Coniacian.	
	a. Marls and gravels with granite pebbles, and with *Prionocyclus serratomarginatus, Pachydiscus vaju, Scaphites, Baculites.*	Turonian.	
1. Uttattur	Uttattur Beds (silts and sands, with a partly denuded coral reef at base). c. Beds with *Puzosia planulata, Acanthoceras naviculare, Mammites conciliatus, M. discoidalis, Neoptychites, Fagesia superstes.* b. Beds with *Acanthoceras newboldi, A. cenomanense, A. naviculare, A. harpax, Turrilites costatus.* a. Beds with alternations of red clay and marls, and with *Phylloceras ellipticum, Gaudryceras sarya Tetragonites timotheanus, Puzosia compressa, Placenticeras warthi, Stoliczkaia dispar, Inflaticeras, Hamites armatus, Turrilites bergeri.* Coral reef limestone at base, the series resting upon gneiss or Upper Gondwanas.	Cenomanian to Uppermost Albian.	

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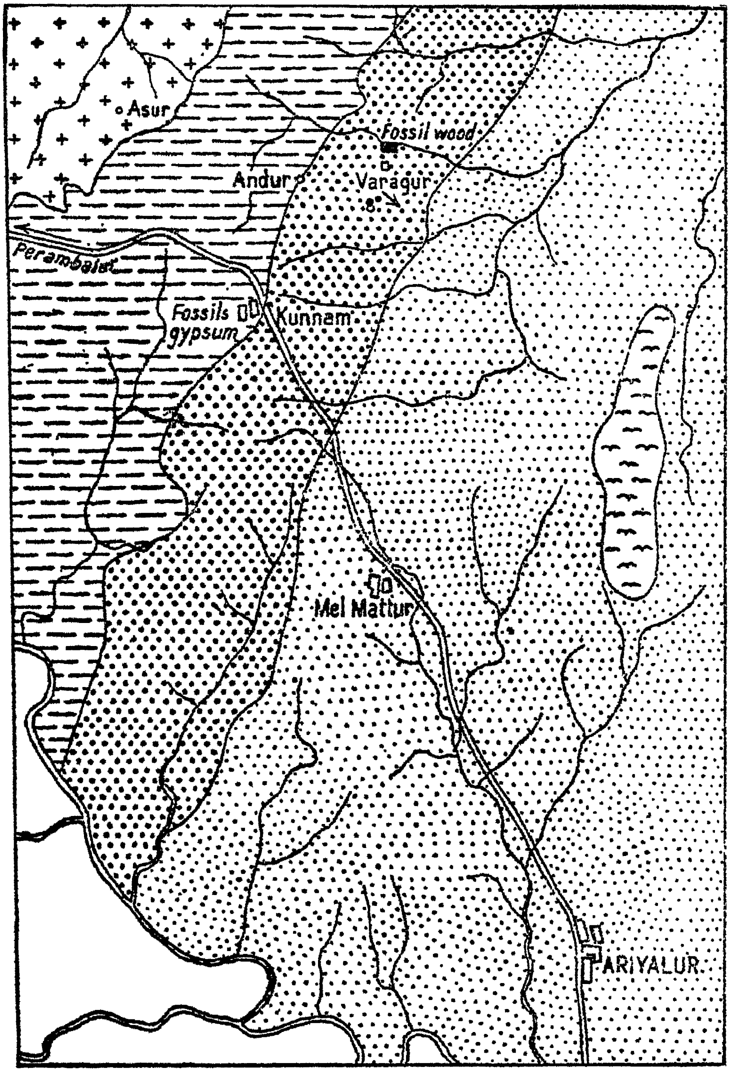
[1] Cotter (38), p. 48.



A PART OF CRETACEOUS ROCKS OF THE TRICHINOPOLY DISTRICT.

SCALE OF MILES.

0 2 4

▤ *Tertiary and Recent*
░ *Ariyalur stage.*
▒ *Trichinopoly stage.*
☰ *Uttattur stage.*
✚ *Gneiss.*
8° ↗ *Dip.*

The rocks in the neighbourhood of Varagur from where the present specimen was collected, belong to the Trichinopoly stage. Here the whole area is generally covered by a thin mantle of black soil, but the strata are seen exposed in the shallow streams which are dry for the greater part of the year. The rocks, chiefly composed of arenaceous limestone, sandstone and clay, have a gentle dip eastwards or E. S. E. varying from 6 to 15 degrees. About a mile east of Varagur the rocks of the Trichinopoly stage are seen immediately overlain by those of the Ariyalur stage. Remains of ammonites, lamellibranchs and gastropods are abundant. The specimen described in these pages was discovered in the middle portion of the Trichinopoly stage about 500 feet from the base. It was not found *in situ* ; but from its position in the field there is hardly any doubt that it was derived from the middle beds of the Trichinopoly stage. Several other fragments of fossil wood, mostly ill-preserved and indeterminable, were also found associated with *Pseudocycadeoidea*.

Besides Varagur there are other fossiliferous localities in the Trichinopoly stage from where trunks and fragments of fossil wood have been reported. One interesting occurrence is near Sattanur (11°9′20″:78°58′30″), about half a mile north of the village in the lower beds of the same stage. A large branched fossil trunk measuring about 65 ft. (and there is every indication to show that it might originally have been 75 ft. or more in length), is seen lying *in situ* in the yellow limestone. Blanford[1] has already reported the occurrence of large trunks particularly in the upper beds of the Trichinopoly stage, some of them measuring not less than sixty feet in length.

Pieces of the large trunk from the Trichinopoly beds found near Sattanur were brought to Calcutta, but the preservation of the internal tissues was found to be too poor even for generic determination. It seems very likely, however, that the wood is of coniferous affinity. It is quite probable that such large coniferous trees formed part of the associated vegetation of the period in several parts of the world where the cycadeoideans flourished in all luxuriance. In this connection it may be recalled that in association with the cycadeoideans from the Purbeck beds of the Isle of Portland[2], from the Potomac beds of Maryland[3] and from other localities in the United States of America, large coniferous trunks have been reported.

[1] Blanford (65), pp. 117, 118, fig. 13.

[2] Ward (94-95), Pl. CII, refigured (Fitton's).

[3] Ward (00), Pl. LXXXI.

Large trunks of fossil wood, mostly opalised, are also found on the banks of streams south and south-east of Alundalippur (11°3′:78°55′) and also in the triangular area formed by the three villages, Alundalippur, Garudamangalam (11°5′:78°55′10″) and Saradamangalam (11°30′30″:78°57′10″).

DESCRIPTION

The specimen represents a low, unbranched, somewhat vertically compressed "trunk" the striking feature of which is the presence of bud-like rosettes possibly representing fertile shoots among rhomboidal or sub-rhomboidal leaf bases (Pl. 12, fig. 3). When viewed from above, the "trunk" has more or less an oval outline (Pl. 11, fig. 1). It is of a reddish brown colour. The maximum height of the specimen is about 12 cm., the greatest length about 37·2 cm. and breadth 29 cm. In general, the habit of this plant was probably not very unlike that of species of *Macrozamia* or *Encephalartos.* The upper part of the specimen is somewhat dome-shaped while the under side is more or less hollowed out and shows no distinct structures except a few small shallow circular cavities which probably indicate the original position of the "shoots" (Pl. 12, fig. 2).

The lower part of the specimen, as already noted above, is hollowed out. The leaf bases and the shoots, however, show a tendency to converge towards a hypothetical central axis which was probably very short and stumpy.

Normally a terminal bud is present in the cycadeoideans and is clearly marked in well preserved stems. It may be that in the present example it is either not preserved or is lost sight of amongst the several cushion-shaped top parts of the "shoots". In other cycadeoideans the terminal bud, when present, is seen as a small conical projection (*Cycadeoidea marshiana*[1]) or, as in other cases, it might appear sunk in a small apical cavity the presence of which gave rise to the popular name "crow's nest" amongst the Portland quarrymen for the Purbeck cycadeoideans.

Leaf bases.—The surface of the specimen is covered over by an armour of persistent leaf-bases very much as in the living cycads. The preserved length of the leaf base or the depth of the armour may be as much as 6 cm. or sometimes even longer. The ramental scales characteristic of *Cycadeoidea* are not distinguishable, but in their place are seen certain tubular hairs.

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[1] Wieland (06), Pl. V, fig. 1. Seward (97).

In some parts of the specimen the leaf bases are preserved almost flush with the surface of the specimen (*b*, Pl. 11); in certain other parts, in place of the preserved leaf bases, rhomboidal or sub-rhomboidal cavities are seen surrounded by a fairly thin reticulum (*c*, Pl. 11 ; Pl. 13, figs. 4, 5). These cavities represent the position of the original leaf bases from which the petrified material has been partly removed at a later period due to weathering. The prominent reticulum represents the more resistant parts of the leaf bases.

The normal arrangement of these leaf bases is in spiral order (Pl. 13, figs. 4, 5), but owing to the interpolation of several " shoots " amongst them which thrust the leaf bases aside and, to a certain extent, to slight vertical compression which the specimen as a whole seems to have undergone, the spiral arrangement of the leaf bases has been lost in some parts.

The leaf bases are of fairly small size the longer axis measuring 6 mm. and the shorter 2 mm. on an average. The larger leaf bases may measure even 8 mm. × 4 mm. The shape of the leaf scar or base may be described as rhombic to sub-rhombic. In some of them the two sides of the upper half (adaxial) meet at a wide angle and curve inwards. In others the distinction between the two sides is lost and the adaxial side is seen to run almost in a straight line. In the lower half of the leaf base (abaxial) the two sides, in the case of the older leaf scars, merge into a smooth outwardly projecting curve, or else, retain their individuality and run straight meeting at a wide angle. The preserved leaf bases are of ash grey colour and, on the whole, give an idea that originally their structure was somewhat " spongy ". Very often the position of the leaf base is indicated by rhomboidal cavities. There is hardly any sharp distinction in size between the leaf scars and the outer scars that surround the " shoots " as a protective covering. In the majority of the cycadeoideans the two are clearly distinguishable. In the present specimen, however, the leaf-scars gradually become smaller as the centre of the " shoot " is approached.

The leaf bases do not show any clear indication of vascular bundles. One of the bases, however, reveals faint marks of about 10-12 separate bundles arranged in a series following the outline of the leaf base. A U- or V-shaped invagination in the upper row of bundles, if present at all, is not clear. In the absence of any clear indication of vascular bundles in any other leaf base, it has not been possible to make any comparison with similar structures in the described species of *Cycadeoidea*.

One of the leaf scars shows very faintly a black, apparently continuous, sinuous line running along the inner margin of the scar. This may represent an outer tissue composed of thick-walled cells.

The ramenta are not easily distinguishable. A yellowish-brown reticulum is present between the leaf bases, the thickness of which is variable, usually from 0·5 mm. to 1·0 mm.

Axillary " shoots ".—Viewed from the upper surface, axillary shoots appear as small projecting cushions with the smaller scars spirally arranged. As already noted above, an external examination of the specimen hardly reveals any clear distinction between the scars immediately surrounding the shoots and the older scars, except in a gradual difference in size.

At least forty " shoots " are counted in our specimen, all of them apparently of the same age. If we may draw a comparison with the fertile shoots of *Cycadeoidea,* this number is not very great. In the famous American Hermosa cycadeoidean, *C. dartoni,* in the preserved part of the specimen, more than five hundred fertile shoots have been counted[1]. As Wieland[2] points out (and Seward[3] agrees with him), after a considerable period of vegetative growth the cycadeoideans probably produced large crops of reproductive shoots almost simultaneously, and after fruiting only once in their life time, came to total extinction. In the absence of any well-preserved internal structures we are reluctant to speculate on the true nature of the axillary shoots in *Pseudocycadeoidea.*

The underside of the specimen reveals several circular or oval cavities or areas which represent the eroded core of the " shoots " (*sc.,* Pl. 12, fig. 2) not very unlike those seen in a specimen of *C. wielandi*[4]. The circular or oval scars measure about 1·2 to 2·7 cm. in diameter. At one place at least five such cavities or scars, crowded in a small area, are visible (*sc.,* 1, 2, 3, 4, 5, Pl. 12, fig. 2). Each one of these is demarcated by narrow, relatively resistant walls which stand out more prominently than the rest of the tissues in that area (*w.,* Pl. 12, fig. 2). Traces of smaller leaf-scars are clearly seen surrounding the eroded surface of the " shoots " in the right upper half of Pl. 12, fig. 2. All the shoot scars are not of equal size, partly because of their erosion at different levels.

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[1] Wieland (16), p. 99 ; Pls. 38, 39 and 41.

[2] Wieland (06).

[3] Seward (17), p. 381.

[4] Wieland (06), p. 268 ; Pl. XXII, fig. 1.

A few of the "shoots" are seen in longitudinal section along the eroded sides of the specimen (*ev.*, Pl. 12, fig. 2). But they hardly reveal features of importance. At least one of them shows very indistinctly the envelope of leaves or bracts in vertical section spirally arranged round a central cavity (Pl. 13, figs. 6, 7). Whether the latter represents the original position of the receptacle and the essential organs which have fallen off, is not known definitely.

At a spot marked (*v*) in Pl. 13, figs. 6, 7, a slight constriction in the cavity is seen towards the basal part. In this connection one is inclined to recall the structure of the fertile short of *Cycadeoidea.* If such a comparison is permissible it is possible to interpret that below the constriction mentioned above, lies the region probably occupied by the enlarged head of a receptacle or some such structure on which the reproductive elements were attached. The figures (*v.*, Pl. 13, figs. 6, 7) may suggest that the receptacle was short, hemispherical and cushion-shaped as in the case of C. *wielandi*[1] or C. *turrita*[2] and did not project as a conical structure as in C. *dacotensis*[3].

DISCUSSION

General

The Trichinopoly specimen shows the closest external resemblance with *Cycadeoidea.* But as the internal structure is not seen well preserved in thin sections to justify a generic identification with *Cycadeoidea,* and as a more closer comparison with any known fossils so far described, is not possible, the authors prefer to create a new genus, *Pseudocycadeoidea,* to accommodate this interesting find from Trichinopoly.

The short and stumpy habit, the presence of several cushion-shaped "shoots" surrounded by the preserved leaf stalks arranged rosette-wise, and the (?) separate vascular strands (though very faintly discernible) arranged in a series following the outline of the leaf base, recall *Cycadeoidea.* But there are certain features which militate against its identification with that genus.

Apical bud and axis.—There is no clear indication of an apical bud which in the majority of *Cycadeoidea* generally occurs either as a small projecting cone quite distinct from the reproductive shoots at the apex of the stem, or in a depression at the apex. It is not unlikely that in our specimen an apical bud was probably present, and its distinctiveness lost by the crowded growth of numerous shoots; but we have no satisfactory evidence to sustain this view.

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[1] Wieland (06), p. 110, fig. 56 ; Pl. XXIV, fig. 3.

[2] Wieland (06), p. 129, fig. 64 ; Pl. XXIV, fig. 2.

[3] Wieland (06), pp. 144, 145 ; figs. 71, 72 ; Pl. XXXIX, fig. 4 ; Pl. XXXVI, figs. 1, 2.

Coupled with this fact is the absence of any definite trace of a central axis on which the reproductive shoots were attached. In almost all the previously recorded cycadeoideans, even in the absence of a definitely recognisable apical bud, a central axis has almost always been noticed. The absence of any such axial structure in our specimen is an important feature.

If we take into account the general direction of the several reproductive shoots as revealed in longitudinal sections seen along the sides of the specimen, we get some idea of the probable original position of a trunk from which the several shoots budded out. In any case we do not think it likely that the original axis occupied the whole basal part represented by the deep hollow on the underside of the specimen. It is true that a good deal of the lower part of the specimen has not been preserved and unless more complete specimens are forthcoming it is difficult to arrive at any definite conclusion regarding the actual size and general structure of the whole plant.

Habit.—If we accept the close external resemblance of our specimen with certain cycadeoideans, we may perhaps attempt to picture its probable habit in the light of available information on the known cycadeoideans. Cycadeoideans exhibit wide variations in trunk forms. They may be of "low" habit and very often of conical oval shape as in the case of our specimen. Some forms are branched, others are cylindrical and reach a height of over a metre. But we are not immediately concerned with such forms.

Whether or not the Indian specimen has undergone considerable change in shape owing to vertical compression during the course of preservation is worth consideration. The sectional view of some of the reproductive shoots seen along the sides of the specimen (Pl. 13, fig. 6) seems to indicate that there has been a slight distortion. However, we are of the opinion that the distortion has not been such as to have changed the original shape of the specimen to any considerable extent.

As regards the probable habit of our specimen, one is strongly reminded of Wieland's[1] figure of the lion's head variety of

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[1] Wieland (06), pp. 26-44.

Cycas revoluta or "*shishi*" of the Japanese horticulturists. Our specimen probably represents the remains of a stocky plant which grew close to the ground, less than a metre in height, and had profuse foliage.

Comparison with other described Genera and Species

In this preliminary account only the external features of the specimen are described and compared with those of some of the previously described fossils. A further comparative study will follow if the internal structures are seen well preserved and deemed worthy of description.

As already mentioned, there are certain distinctive features in our specimen (some no doubt accidents of preservation), not commonly observed in the other species of *Cycadeoidea,* namely, the apparent absence of a well marked central axis, an apical bud and the multicellular ramentum, the small size of the leaf scars and the absence of any marked difference in size between the older leaf scars and those surrounding the shoots. As only to be expected, our specimen does not show close similarity with any of the previously described species.

In its general form the Indian species exhibits a very remote resemblance with some of the low growing trunks of *Cycadeoidea dacotensis*[1]. But as seen in Plate 13 of Wieland's memoir[2] on the American Fossil Cycades, Vol. II, the species vary considerably in general form and size, some of them being very definitely columnar. As far as *C. dacotensis* is concerned, the short and hemispherical form of trunk is, probably to some extent, due to vertical compression. As already pointed out, the view of some of the shoots of the Indian specimen in the longitudinal section shown in Pl. 13, fig. 7, does not seem to indicate that the form of our specimen has suffered much by excessive compression in the course of preservation. Again, such characters as the presence of a prominent terminal bud and the large leaf scars quite distinct from the bracts, certainly show that the relationship of our specimen with *C. dacotensis* is not close. The internal structures of *C. dacotensis* are fairly well known; and we are inclined to think that, when the anatomical details of the Indian specimen are also known, it will show further important points of difference.

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[1] Wieland (06), Pl. V. fig. 2.

[2] Wieland (06).

Another species which can only be remotely compared is the smaller branches of *C. nana*[1]. It is not certain if the Trichinopoly cycadeoidean remained throughout unbranched or formed part of a branched stem which got separated from the parent axis. At present, however, we have no evidence to show that our specimen is part of a branched form. But in *C. nana* even in the branches the apical bud is well marked, and the leaf bases (which are relatively large) and the bracts are fairly well differentiated in mature specimens. Recently, Wieland[2] figured two branched specimens doubtfully referred to *C. nana.* In both the bract areoles are absent, a feature which, according to Wieland, is due to the fact that they are in "pre-fruit stage of growth". The frond bases are 10 mm. broad (longest axis) and 5 mm. high. It seems unlikely that the bracts are undeveloped in our specimen, as externally there is every indication of differentiation of fertile shoots in the form of characteristic rosettes. In sectional view too (Pl. 13, fig. 6), there is every indication of maturity. We believe then, that the lack of distinct differentiation between the leaf stalks and the bract areoles is a definite feature and not due to the immaturity of the Indian specimen. *C. marshiana* from the Bologna Museum of Italy figured by Capellini[3] seems at first sight to resemble the Indian specimen in external appearance, but the specimens referred to this species are usually branched[4] ; besides, the leaf bases are of larger size and the passage of these to the bracts is fairly abrupt.

From the above attempt at comparison with some of the known species, it will be admitted that there are hardly any points of similarity, except perhaps for a remote resemblance in general external appearance. In the absence of a pronounced apical bud and the comparatively small size of the leaf bases which show a very gradual reduction in size on approaching the centre of the shoots, our specimen is unique. As only to be expected, the American and Italian species of *Cycadeoidea* with which our specimen has been distantly compared, are much too different even in external appearance and remote in time and geographical position to admit of any close similarity.

We are unable to identify the Indian specimen with any fossil known to us. It is therefore described as a new genus and we propose the name *Pseudocycadeoidea indica* to accommodate this new form.

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[1] Wieland (06), Pl. VI, fig. 3 ; (16), Pl. 37, (41).

[2] Wieland (41), Pl. V, figs. IA, IB.

[3] Capellini (09), Pl. 1, fig. 1.

[4] Wieland (16), Pls. 21-24.

The internal structures of *P. indica* are unknown at present. Even admitting the severe limitation of depending on the external features alone for the creation of a new genus, it is evident that the characters mentioned above are fairly distinctive. The diagnosis of the species given below is therefore confined to its external features. Further search for such specimens will be well worth the trouble, and it is likely that better preserved specimens may be discovered on some future date from the Trichinopoly area. The affinities of our specimen are at present unknown.

PSEUDOCYCADEOIDEA INDICA gen. et sp. nov.

Diagnosis.—Trunk low, unbranched (?), dome-shaped, elliptical in outline, covered by persistent leaf bases embedded in a reticulum of yellowish-brown ramenta (0·5-1 mm) of unicellular tubular hairs and studded with numerous, small, projecting, cushion-shaped, rosette-like "shoots". (Terminal bud and central axis unrecognisable) : leaf bases small, average 6-8 mm. broad and 2-4 mm. high, rhomboidal or sub-rhomboidal, leaf scars and bract areoles not sharply distinguished. ? Thalamus of reproductive shoot short(?) and cushion-shaped varying from 1·2 cm. to 2·1 cm.

Horizon.—Upper Turonian or Lower Senonian, Trichinopoly stage, Upper Cretaceous.

Locality.—About 3 furlongs North-West of Varagur, 8 miles N. N.-W. of Ariyalur Railway Station, Trichinopoly district, South India.

Specimen.—(K. 42/690) G.S.I. Type No. 17,455.

AGE OF THE BEDS

Our specimen is described as a new genus and cannot be of value in fixing the age of the beds. The associated plant remains are composed of badly preserved and indeterminable fossil wood and are worthless as indicators of age. A doubtful occurrence of a "Zamia frond" is also known from the basal beds of the Trichinopoly stage[1]. By itself this record is not helpful in fixing the age of the beds.

The beds of the Trichinopoly stage have, however, yielded abundant well preserved marine fossils which have been described by Stoliczka[1] and later by Kossmat[2]. The former[3] correlates the Trichinopoly formations with those of the European Cretaceous and, on the faunal evidence, broadly compares the basal Uttattur stage with Cenomanian, the Trichinopoly with the Turonian and the Ariyalur with the Senonian. The evidence, according to Kossmat[4], indicates a Turonian-Senonian age for the Trichinopoly stage. The middle beds from which *Pseudocycadeoidea indica* gen. et sp. nov. is derived, are to be referred probably to the Upper Turonian or Lower Senonian. Cotter[5] also assigns a Turonian-Santonian age to the Trichinopoly stage.

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[1] Blanford (65), p. 49.

SUMMARY

1. The specimen from the Trichinopoly stage of South India is described as a new genus, *Pseudocycadeoidea indica.* In the present paper only the external features are described. A superficial resemblance is recognised with the Mesozoic genus *Cycadeoidea.* No other fossil approaches this interesting find from the Trichinopoly district even in external features. The few sections so far prepared give no satisfactory indication of the internal structure of the fossil. Its affinities are at present unknown.

2. *Pseudocycadeoidea* being a new genus, is by itself of no great value in fixing the age of the beds. But the associated rich marine fauna already described previously by Stoliczka and Kossmat, indicates a Turonian-Lower Senonian age for the Trichinopoly stage. The middle beds from which *P. indica* is derived are to be referred probably to the Upper Turonian or Lower Senonian.

We are grateful to Dr. M. S. Krishnan, Director, Geological Survey of India for kindly going through the manuscript and making valuable suggestions.

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[1] Stoliczka (65-73).

[2] Kossmat (95).

[3] Stoliczka (65-73)', Ser., VIII, Vol. IV, p.11.

[4] Kossmat (95*a*), p. 40.

[5] Cotter (38), p. 48.

LIST OF REFERENCES.

Blanford, H. F. (1865) . . . On the Cretaceous and other rocks of the South Arcot and Trichinopoly districts, Madras. *Mem. Geol. Surv. Ind.*, Vol. IV, Pt. 1.

Buckland W. (1827) . . . *Proc. Geol. Soc.* London., Vol. No. 8

Buckland W. (1828) . . . On the Cycadeoideae, a family of fossil plants found in the Oolitic quarries of the Isle of Portland. *Trans. Geol. Soc. Lond.*, 2nd series, Vol. II.

Capellini, G. (1909) . . . Le Cicadee fossili del Museo Geologico di Bologna. *Mem. Accad. Sc. Inst. Bologna*, Series VI, Vol. VI, p. 121.

Capellini, G. and Conte H. Solms-Laubach, (1892). I tronchi di Bennettitee dei Musei Italiani. Notizie storiche, geologiche, botaniche. *Mem. R. Accad, Sc., Inst.* Bologna, Series V, Vol. II.

Carruthers, W. (1870) . . On fossil cycadean stems from the secondary rocks of Britain. *Trans. Linn. Soc.*, Vol. XXVI.

Cotter, G. de P. (1938) . . The Indian Peninsula and Ceylon. *Regionale Geologie der Erde,* ed. K. Andree, H. Brouwer and W. H. Bucher, Bd. 1, Abt. VI, *Leipzig.*

Dawson, J. W. and Harrington, B.A. (1871). Report on the Geological structure and mineral resources of Prince Edward Island. *Montreal.*

Endo, S. (1925) . . . . . Nilssonia-bed of Hôkkaidô and its flora. *Sci. Rep. Tohuku Imp. Univ. Sendai, Japan, Second series (Geology),* Vol. VII, No. 3.

Kossmat, F. (1895) . . . On the importance of the Cretaceous rocks of Southern India in estimating the geographical conditions during later Cretaceous times. *Rec. Geol. Surv. Ind.*, Vol. XXVIII, Pt. 2.

Kossmat F. (1895*a*). . . . Untersuchungen über die südindische Kreideformation. *Beitr. z. Paläon. Osterr-ung.*, Bd. IX, Bd. XI.

Krausel, R. (1925) . . . Raumeria Reichenbachiana und ihre verwandten ausgestorbenen Cycadophyten des Mesozoikums. *Senck. natürforsch. Ges. Bericht,* 55.

Krishnan, M. S. (1949) . . Geology of India and Burma. *Madras.*

Kryshtofovich, A. (1920) . . A Cycadean trunk from Hôkkaidô. *Jour. Geol. Soc. Tokyo,* Vol. XXVII.

Lignier, O. (1894) . . . Végétaux fossiles de Normandie. Structure et affinité du *Bennettites Morierei* Sap. and Mar. (sp), *Mém. Soc. Linn. Normand.*, Vol. XVIII.

Lignier, O. (1901) . . . Végétaux fossiles de Normandie. Etude anatomique du Cycadeoidea micromeyla Mor. *Mém. Soc. Linn. Normand.* Vol. XX.

Madigan, C. T. (1944) . . Central Australia. *Melbourne.*

Moriere, J. (1869) . . . Note sur deux végétaux fossiles trouves dans le departement du Calvados. *Mém. Soc. Linn. Normand.* Vol. XV, No. 7.

Sahni, B. (1922) . . . The present position of Indian palaeobotany. Pres. Addr. 8th Ind. Sci. Congr., *Proc. As. Soc. Bengal* (*New Series*), Vol. XVII, No. 4.

Seward, A. C. (1897) . . . On *Cycadeoidea gigantea,* a new cycadean stem from the Purbeck beds of Portland. *Quart. Journ. Geol. Soc.*. Vol. 53.

Seward, A. C. (1917) . . . Fossil plants Vol. III. *Cambridge.*

Seward, A. C. (1933) . . . Plant life through the ages. *Cambridge.*

Stoliczka, F. and Blandford, H. F. (1865-73). Cretaceous fauna of Southern India. *Pal. Ind., Ser.* I, III, V, VI, VIII, Vols. 1-4.

Ward, L. F. (1894-95) . . Some analogies in the Lower Cretaceous of Europe and America *16th Ann, Rep., U. S. Geol. Surv.*

Ward, L. F. (1900) . . . Status of the Mesozoic floras of the United States. *20th Ann. Rep., U. S. Geol. Surv.*

Wieland, G. R. (1906) . . . American fossil Cycads, Vol. 1, *Carn. Inst. Washington.*

Wieland, G. R. (1916) . . . American fossil Cycads, Vol. II. *Carn. Inst. Washington.*

Wieland, G. R. (1934) . . . Fossil cycads, with special reference to *Raumeria Reichenbachiana* Geoppert sp. of the Zwinger of Dresden. *Palaeontogr.* Bd. LXXIX, abt. B.

Wieland, G. R. (1941) . . . The Carpathian-Black Hills Cycadeoid parallel. *Am. Journ., Sci.,* Vol. 239, No. 7.

EXPLANATION OF PLATES.

The specimen is preserved in the Museum of the Geological Survey of India, Calcutta.

PLATE 11. Figure 1.—View of specimen from the top. *b.*, area showing the spirally arranged leaf bases preserved flush with the surface of the specimen. *c.*, area showing the reticulum in which the leaf bases are embedded. × ca 0·4.

PLATE 12. Figure 2.—View of specimen from below, *e. v.*, position of two of the "shoots" seen in sectional view along the eroded side of the specimen (shown under higher magnification in Pl. III, figs. 6, 7). *sc.* 1-5, circular or oval cavities probably representing the eroded surface of "shoots". *w.*, resistant walls of the leaf bases. ×ca 0·3.

Figure 3.—View of specimen from one side. × ca 0·3.

PLATE 13. Figure 4.—One of the "rosettes" magnified showing spirally arranged scars. × ca 1·5.

Figure 5.—Another "rosette" magnified showing spirally arranged scars. × ca 5·4.

Figure 6.—Three cavities representing the original position of the tissues of the "shoots" seen in vertical section on the eroded surface of the specimen. *v.*, constriction in the cavity × ca 0·9.

Figure 7.—Cavity in the extreme right of Figure 6 further enlarged showing the constriction (*v.*) × ca. 1·4.

MIOCENE FORAMINIFERA FROM CHAVARA, NEAR QUILON, TRAVANCORE.

BY K. JACOB, D.SC., F.G.S., F.N.I., *Palaeontologist* and V. V. SASTRI, M.SC., *Geological Assistant, Geological Survey of India.* (With Plates 14 to 16.)

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INTRODUCTION

A set of core-samples from a trial bore-hole sunk for water investigations at Chavara (8° 58′:76° 32′), near Quilon, was forwarded to the Geological Survey in 1950 for palaeontological examination. The samples were kindly sent by T. R. M. Lawrie, then Director, Mineral Survey and Research, Central Research Institute, Trivandrum. This bore-hole cut a fossiliferous horizon (which Lawrie thinks to be probably the Quilon beds), at a depth of between 170 and 190 feet from the surface and went on through fossiliferous clays, calcareous sands and grits up to a depth of 280 feet. The samples were collected at 5-foot intervals from 170 feet down to 280 feet below the surface. The material is fairly rich in Foraminifera and Mollusca, and in this paper the results of the preliminary foraminiferal investigations are reported. Two interesting Bryozoans found in the core-samples are also figured.

Operculines are abundantly represented in the samples while Lepidocyclines and *Gypsina* are less common. Smaller Foraminifera, Ostracoda and Bryozoa occur rarely.

SYSTEMATIC DESCRIPTION OF THE FORAMINIFERA

Family *CAMERINIDAE*

Sub-family *CAMERININAE*

Genus OPERCULINELLA Yabe, 1918

OPERCULINELLA VENOSA (Ficht. and Moll)

Pl. 14, fig. 1. Pl. 16, figs. 18, 19.

This interesting operculine is present in the samples both in its young and adult stages of growth. There are a few megalospheric involute forms that are nummulite-like in appearance, and also some microspheric complanate forms with a broad test and raised sutures. Yabe and Hanzawa[1] give a fine descriptive account of this species and their photographs seem to tally with ours quite closely. This form is present in almost all the core-samples.

G. S. I. Nos. 17,440 ; 17,451 ; 17,452

OPERCULINELLA LAWRIEANA sp. nov.

Pl. 14, figs. 2a, 2b. Pl. 16, figs. 17a, 17b.

Test discoidal, slightly elongate, bilaterally symmetrical, involute in the early stages tending to become evolute in the later stages of growth ; central portion thickened and slightly umbonate, consisting of three whorls, the last formed made up of 15-17 chambers, with short slightly curved sutures externally not visible, coated with a thick layer of calcareous matter ; aperture at the base of the apertural face, median. This is found to occur, though in small numbers in all the samples.

Length—2 mm.; breadth—1·3 mm.; thickness—0·5 mm.

None of the known species compares favourably with this form and we are inclined to keep it tentatively in a new species for which we propose the name *O. lawrieana.* Further study of this species is in progress.

G. S. I. Type Nos. 17,441 ; 17,450

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[1] Yabe and Hanzawa (1925), p. 49, Pl. V, figs. 1-27, Pl. VI, figs. 1-5, Pl. VIII, figs. 1-10.

Genus OPERCULINA d'Orbigny, 1826

OPERCULINA GRANULOSA Leymerie

Pl. 14, fig. 3. Pl. 16, fig. 13.

Test thick, consisting of nearly two whorls, the outer one made up of about 20 chambers with raised and granulated sutures. Well developed peripheral keel is present. The central portion of the test is sometimes composed of closely packed granules.

Length—3·5 mm.; breadth—2·5 mm.; thickness—0 75 mm.

This widely occurring species present in our collection, shows a fair degree of variation, as already recorded by others. There is some resemblance with *O. bartschi* var. *ornata* Cush.[1] which is found in the seas near the Philippines, but Yabe and Hanzawa's[2] figured specimens of the same species do not show any close similarity to our form.

G. S. I. No. 17,442.

OPERCULINA BARTSCHI Cushman

Pl. 14, fig. 4. Pl. 16, fig. 14.

Test moderately thick, consists of about two and a half whorls, the last one made up of 20 to 25 chambers; the sutures are well defined and the entire surface of the test is finely and regularly granulated, but less conspicuous than in *O. granulosa.* The central portion of the test is slightly raised and is sometimes spotted with small granules. There is no definite marginal keel, but the periphery is fairly thick.

Length—3 mm.; breadth—2 mm.; thickness—0 4 mm.

This form can be easily differentiated from *O. granulosa* Leym. in the nature and extent of ornamentation of the test. Cushman[3] records this species from the seas near the Philippines, Hanzawa[4] from Japan, and Cole[5] from the Fiji Islands.

G. S. I. No. 17,443

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[1] Cushman (1921), p. 378, Pl. 74, figs. 2a, 2b.

[2] Yabe and Hanzawa (1927-29), p. 184, Pl. XVIII, figs. 10-12.

[3] Cushman (1921), p. 376, fig. 13.

[4] Hanzawa (1935), p. 22, Pl. II.

[5] Cole (1945), p. 277, Pl. XII, figs. H-K, Pl. XIV, fig. I.

OPERCULINA MALABARICA sp. nov.

Pl. 15, fig. 6. Pl. 16, fig. 15.

Test thin, flat, bilaterally symmetrical, planispiral, complanate with two to three whorls, the last formed made up of about 25 chambers, rapidly increasing in height, the sutures evenly curved, non-limbate, not clearly visible on the surface; wall finely perforate, surface smooth with the central portion raised into a small knob; aperture a curved slit at the base of the apertural face. This and the other two species of *Operculina* are present in fair numbers in the entire sampled portion of the bore-hole.

Length—4 mm.; breadth—3·2 mm.; thickness—0·20 to 0·30 mm.

This species shows a general resemblance to *O. complanata* (Defr.)[1], but differs from it in the absence of the interseptal canal system on the anterior side of each chamber, a distinguishing feature of the latter species, as pointed out by Chapman and Parr.[2] The other comparable forms are *O. complanata* var. *japonica* Hanz.[3] and *O. bartschi* var. *plana* Cush.[4] The former is described and figured as having slightly raised sutures and 'ornamented with bead-like pustules'. Hanzawa's and Cole's[5] photographs of the same do not suggest any close similarity with our form. In Cushman's original description of *O. bartschi* var. *plana* the initial portion of the test is reported to be granulated and Yabe and Hanzawa's[6] figures show some important differences with ours.

We are inclined to consider the present form as different from the above mentioned species and we suggest the new name, *O. malabarica*. Probably the form recorded as *O.* cf. *complanata* by Kumar and Pichamuthu[7] from the Quilon beds at Chattanur is to be referred to *O. malabarica*. We have not come across any Operculine in the limestone at Padappakara.

G. S. I. Type Nos. 17,444; 17,449

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[1] Defrance (1822), p. 453.

[2] Chapman and Parr (1938), p. 281, Pl. XVI, figs. 1, 2, text fig. 1.

[3] Hanzawa (1935), p. 19, Pl. I, figs. 4-28.

[4] Cushman (1921), p. 377, fig. 14.

[5] Cole (1945), p. 278, Pl. XII, figs. D-G, Pl. XIII, figs. F-I.

[6] Yabe and Hanzawa (1927-29), p. 184, Pl. XVIII, figs. 13-15.

[7] Kumar and Pichamuthu (1933), p. 91.

Genus GYPSINA Carter, 1877

GYPSINA GLOBULUS (Reuss)

This common globular form is present in strikingly large numbers and has a very short range in the core between 250 to 270 feet.

Diameter—About 2 mm.

G. S. I. No. K. 45/538

Family *ORBITOIDIDAE*

Genus LEPIDOCYCLINA Gümbel, 1870

LEPIDOCYCLINA sp.

There are only three incomplete specimens, all obtained from one sample. The test seems to be almost uniformly thick (1·75 mm.) and evenly granulated. Due to the limited number of forms at present available, it was not possible to obtain satisfactory details for specific determination. These are recovered from the sample at 170-175 feet below the surface.

G. S. I. No. K. 45/539

Sub-genus NEPHROLEPIDINA Douvillé, 1911

NEPHROLEPIDINA SUMATRENSIS (Brady)

Pl. 15, fig. 8. Pl. 16, fig. 16.

Test small, discoidal, bilaterally symmetrical, the central region on both sides more coarsely and densely granulated than the peripheral portion. Horizontal sections show typical Nephrolepidine type of initial chambers. The well-preserved specimens are about 2 mm. in diameter. The protoconch and the deuteroconch measure about 0·20 mm. and 0·35 mm. respectively. This species is found to occur in the entire length of the sampled portion of the core.

G. S. I. No. 17,447

NEPHROLEPIDINA cf. MARGINATA (Michelotti)

A few well preserved forms resembling *Nephrolepidina marginata* are present in our samples, the largest specimen measuring about 11 mm. in diameter. The central portion bulges out on both sides of the test and is thickly and finely granulated with an expanded peripheral flange which makes up the major portion of the test. The horizontal section of this species (not figured here) resembles those figured by Lemoine and Douvillé.[1] We suspect the presence of megalospheric forms as well in our material, represented by a few smaller specimens which externally answer to the type description.

Pending further investigation these forms are provisionally compared to *N. marginata* which occurs in the Lower Gaj series.

G. S. I. No. K. 45/541

NEPHROLEPIDINA CHAVARANA sp. nov.

Pl. 15, figs. 9a, 9b. Pl. 16, figs. 12a, 12b.

Test lenticular, the two sides bulging out symmetrically on either side with a short, wavy, peripheral, expanded flange separating them and giving the peculiar saddle-shape to the form. Central portion of the test on either side is studded with coarse pustules which diminish in size and number towards the periphery. The initial chambers are Nephrolepidine in character. (Crespin[2] in her paper on the genus *Lepidocyclina* suggests that the Trybliolepidine characters are more dominant in some of the Indo-Pacific species. But we would prefer, for the present, to recognise only the Nephrolepidine forms here.) There are no pillars seen in the meridian section. In the equatorial section four well developed rays are visible extending from the centre towards the four corners of the test; the median chambers are spatulate. In the rayed portion they tend to become hexagonal. The protoconch and the deuteroconch measure about 0·25 mm. and 0·40 mm. respectively. This form is associated with *N. sumatrensis* and is recorded from some of the core samples in varying numbers.

Length—2·5 mm.; breadth—2·4 mm.; thickness—1·25 mm.

This form differs from *N. sumatrensis* (with which it shows the closest resemblance), in the shape of the test and in possessing the characteristic rays as seen in the equatorial section. So far as we are aware, our form does not tally with any of the species hitherto described. We propose the name *N. chavarana* for this new and interesting form from Chavara.

G. S. I. Type Nos. 17,448 ; 17,453 ; 17,454

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[1] Lemoine and Douvillé (1904), p. 16, Pl. III, figs. 3, 8, 9, 13.

[2] Crespin (1943), pp. 157-194.

Besides the genera and species described above, the other associated Foraminifera occurring at various depths in the bore-hole include *Textularia* sp., *Quinqueloculina bicornis* (Walk. and *Jac.*), *Quinqueloculina* sp., *Spiroloculina* sp., *Pyrgo bulloides* (d'Orb.), *Nonion scapha* (Ficht. & Moll), *Elphidium* sp., *Lagena striata* (d'Orb.), *Archaias malabaricus* (Carter), *Reussella spinulosa* (Reuss), *Discorbis* cf. *cycloclypeus* Parr, *Eponides* sp., *Rotalia* sp., *Asterigerina* sp., *Amphistegina lessonii* d'Orb. and *Cibicides* sp.

Among the Ostracoda?*Cytherella* sp., *Bairdia* cf. *foveolata* Brady, *B. amygdaloides* Brady and *Loxoconcha* sp. occur in the core. The Bryozoa are represented by two interesting and comparatively rare forms, probably belonging to the Cheilostomatous genus *Cupularia* which ranges from the Miocene to Recent. They occur in the core between 235-260 ft. below the surface. The two species recognized are figured here without detailed description which will appear in a subsequent paper together with the description of the Lamellibranchs and Gastropods also found in fair abundance in the core material.

The frequency of occurrence of the Foraminifera and Ostracoda in the entire range of the sampled portion of the core is represented in the accompanying distribution chart. Detailed description of the above mentioned smaller Foraminifera and Ostracoda is not given here for the present, as they are of minor importance.

THE AGE OF THE QUILON BEDS

In deducing the tentative age of the Quilon beds we have assumed that the complete bore-hole material belongs to the same stratigraphical unit. It would have been more satisfactory if any available outcrop sample at Chavara had been collected and the remaining upper portion of the bore-hole material, from the surface to 170 feet below, saved for investigation, so that the complete sequence and the changes, if any, in the fauna could have been studied. Assuming that the Quilon beds extend (in all probability) to a depth of 280 ft. or more from the surface, an attempt is made here to interpret our observations in terms of the 'letter-classification' of the Dutch palaeontologists, a classification which of late has been in favour in the Indo-Pacific regional stratigraphic correlation.

A good summary of the previous palaeontological work done in the Quilon area has appeared recently in a paper by Eames[1], wherein brief references are made to the work done by Carter,

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[1] Eames (1950), pp. 233-252.

Douvillé, Davies, Kumar and Pichamuthu, and Furon and Lemoine. His own view seems to be that the Ceylon, Quilon and Kathiawar Miocene marine faunas are apparently of the same age, probably the Upper Gaj, that is, the upper part of the Lower Miocene, and that they were probably all deposited during the same Lower Miocene transgression when the marine Gaj sediments of Sind and Kutch were deposited.

Vredenburg[1] while discussing the age of the Cuddalore Sandstone, refers the Quilon beds to the uppermost Aquitanian on the basis of Carter's identifications of Gen. Cullen's collection of fossils from the area, which he considers to be identical with the Sind or Kutch species. Krishnan[2] mentions that the Quilon and Warkalli beds are referable to the Upper Miocene to Pontian, their fauna in his view bearing some resemblance to the Gaj and Karikal faunas.

Crespin[3] in her article dealing with the Indo-Pacific influences on Australian Tertiary faunal assemblages, gives Tan Sin Hok's[4] scheme which has been modified by Glaessner[5] as follows:—

Neogene . . {
Upper Neogene (formerly 'g'-'h')
Upper Middle Neogene ('f_3')
Lower Middle Neogene ('f_1'-'f_2')
Lower Neogene (Aquitanian 'e' included in Miocene)

In Crespin's Australian Tertiary Correlation Chart, *Nephrolepidina* is mentioned as characteristic of 'f_1' -'f_2' stage and *Austrotrillina* (without *Lepidocyclina*) as indicative of 'f_2'-'f_3' stage, these two stages being grouped under the Middle Miocene. It is stated therein that *Austrotrillina* as indicated by existing records has not been found in the Indo-Pacific region outside Australia in rocks younger than 'f_2'. Glaessner in his article on the Indo-Pacific correlation summarises the general observations on a regional basis. He extends the ranges of *Nephrolepidina* and *Austrotrillina* (both of which are good index fossils) to the top of the Burdigalian (? Upper Gaj) which in turn is correlated with 'f_1'-'f_2'. Taking the above as a fairly safe basis, our fauna recovered from the core-samples may well fit into 'f_1'-'f_2' stage.

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[1] Vredenburg (1907-08), pp. 321-23.

[2] Krishnan (1949), p. 492.

[3] Crespin (1948), pp. 133-142.

[4] Tan Sin Hok (1939), pp. 98-100.

[5] Glaessner (1943), pp. 41-80.

The occurrence of *Nephrolepidina* in the Gaj series of India[1] is well known. Rao[2] records *N. sumatrensis* and *Trillina howchini* from the Miocene of Surat-Broach area which he correlates with the Upper Gaj (Burdigalian). Tipper[3] records Miocene rocks of the Burdigalian stage in the Interview Island, Andamans, containing a species of *Lepidocyclina* which according to Vredenburg[4] is comparable to *N. sumatrensis.* This material is however worth re-examination in the light of recent knowledge. Rao[5] assigns a late Oligocene or an early Miocene age for the *Lepidocyclina* limestone from the Andaman Islands, on the basis of his study of *Lepidocyclina* (s. l.) sp. indet. and other associated foraminifera and calcareous algae from this horizon.

The occurrence of *Austrotrillina* (without *Lepidocyclina*) in the limestone at Padappakara as reported in a previous paper[6] is of additional interest. We do not know at present at what depth below the surface *Lepidocyclina* makes its appearance at Chavara, and we are not aware of any outcrop sample containing *Lepidocyclina* at Chavara.

Thus, taking into consideration the general aspect of the microfauna and following Glaessner's modified 'letter-classification', our fauna as a whole corresponds fairly well with his 'f_1'-'f_2' stage, correlated roughly with the Burdigalian.

ACKNOWLEDGMENTS

We are grateful to Dr. M. S. Krishnan, Director, Geological Survey of India, for his valuable suggestions and to Mr. T. R. M. Lawrie, for kindly sending us the material.

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[1] Vredenburg (1907), pp. 62-67.
Vredenburg (1920), pp. 325.

[2] Rao (1941), pp. 7, 8.

[3] Tipper (1911), p. 203.

[4] Vredenburg (1906), p. 93.

[5] Rao (1942), p. 116.

[6] Jacob and Sastri (1951), pp. 326-327.

LIST OF REFERENCES

CHAPMAN, F. AND PARR, W. J. (1938) . . . Australian and New Zealand species of the foraminiferal genera Operculina and Operculinella. *Proc. Roy. Soc. Vict.*, 50 (N.S.), pp. 279-99.

COLE, W. S. (1945) . . Larger foraminifera. Geology of Lau, Fiji, *Bernice P. Bishop Mus. Bull.*, 181, pp 272-297.

CRESPIN, I. (1943) . . The genus Lepidocyclina in Victoria. *Proc. Roy. Soc. Vict.*, 55 (N.S.), pp. 157-194.

CRESPIN, I. (1948) . . Indo-Pacific influences in Australian Tertiary Foraminiferal assemblages. *Trans. Roy. Soc. South Australia*, 72, pp. 133-142.

CUSHMAN, J. A. (1921) . Foraminifera of the Philippine and adjacent seas. *U. S. Nat. Mus. Bull.*, No. 100, pp. 1-608.

DEFRANCE, M. J. L. (1822) Minéralogie et Géologie. In: Dictionnaire des Sciences Naturelles., Paris 25, pp. 1-485 (Ellis and Messina).

EAMES, F. E. (1950) . On the ages of certain Upper Tertiary beds of Peninsular India and Ceylon. *Geol. Mag.*, LXXXVII, No. 4, pp. 233-252.

GLAESSNER, M. F. (1943) . Problems of stratigraphic correlation in the Indo-Pacific region. *Proc. Roy. Soc. Vict.*, 55 (N.S.), pp. 41-80.

HANZAWA, S. (1935) . Some fossil Operculina and Miogypsina from Japan and their stratigraphical significance. *Sci. Rep. Tohoku Imp. Univ.*, Sr. 2 (Geol.), 18, pp. 1-29.

JACOB, K. AND SASTRI, V. V. (1951) . . . The occurrence of *Austrotrillina* in the Quilon limestone, South India. *Science and Culture*, 16, pp. 326-7.

KRISHNAN, M. S. (1949) . Geology of India and Burma.

KUMAR, C. P. AND PICHAMUTHU, C. S. (1933) . Tertiary limestone at Travancore. *Quart. Jour. Geol. Min. Met. Soc.*, V, pp. 85-98.

LEMOLINE, P. AND DOUVILLÉ R. (1904) . . . Sur le Genre Lepidocyclina Gümbel. *Mem. Soc. Géol. Fr.*, No. 32, pp. 1-40.

RAO, S. R. N. (1941) . The Tertiary sequence near Surat and Broach (Western India) with description of foraminifera of the genus Pellatispira from the Upper Eocene of this region. *Jour. Mys. Univ.*, 2, pp. 5-17.

RAO, S. R. N. (1942) . Calcareous algae of the sub-family Corallineae from a *Lepidocyclina*—limestone from the Andaman Islands. *Proc. 29th Ind. Sci. Cong., Pt. III Abst.*, p. 116.

TAN SIN HOK (1939) . . Remarks on the "Letter Classification" of the East Indian Tertiary. *De. Ing. in Ned-Indie.*, 6, pp. 98-100.

TIPPER, G. H. (1911) . The geology of the Andaman Islands, with reference to the Nicobars. *Mem. Geol. Surv. Ind.*, XXXV, pp. 195-216.

VREDENBURG, E. (1906) . Nummulites douvillé an undescribed species from Kachh with remarks on the zonal distribution of Indian Nummulites. *Rec. Geol. Surv. Ind.*, 34, pp. 79-95.

VREDENBURG, E. (1907) . Note on the distribution of the Genera Orthophragmina and Lepidocyclina in the Nummulitic series of the Indian Empire. *Rec. Geol. Surv. Ind.*, 35, pp. 62-67.

VREDENBURG, E. (1907-8) . Considerations regarding the age of the Cuddalore series. *Rec. Geol. Surv. Ind.*, 36, pp. 321-323.

VREDENBURG, E. (1920) . Note on the marine fossils collected by Mr. Pinfold in the Garo Hills. *Rec. Geol. Surv. Ind.*, 51, pp. 303-337.

YABE, H. AND HANZAWA, S. (1925) . . . . A geological problem concerning the raised coral-reefs of the Riukiu Islands and Taiwan; a consideration based on the fossil foraminifera faunas contained in the raised coral-reef formation and the youngest deposits underlying it. *Sci. Rep. Tohoku Imp. Univ.*, Sr. 2 (Geol.), 7, pp. 29-56.

YABE, H. AND HANZAWA, S. (1927-29) . . . Tertiary foraminiferous rocks of the Philippines. *Sci. Rep. Tohoku Imp. Univ.*, Sr. 2 (Geol.) XI, pp. 137-190.

EXPLANATION OF PLATES

The specimens are preserved in the Museum of the Geological Survey of India.

PLATE 14.

Fig. 1. *Operculinella venosa* (Ficht. & Moll) G.S.I., No. 17440.

Fig. 2a. *Operculinella lawrieana* sp. nov. G.S.I. Type No. 17441.

Fig. 2b. *Operculinella lawrieana* sp. nov. Equatorial section. G.S.I. Type No. 17450.

Fig. 3. *Operculina granulosa* Leymerie. G.S.I. No. 17442.

Fig. 4. *Operculina bartschi* Cushman. G.S.I, No. 17443.

Fig. 5a. *Cupularia* sp. 2 (Bryozoa). Zoecia, G.S.I. No. 17446.

Fig. 5b. *Cupularia* sp. 2 (Bryozoa). Inner tuberose side G.S.I, No. 17446.

PLATE 15.

Fig. 6. *Operculina malabarica* sp. nov. Sectional view in equatorial plane. G.S.I. Type No. 17444.

Fig. 7a. *Cupularia* sp. 1 (Bryozoa). A segment showing the zoecia. G.S.I. No. 17445.

Fig. 7b. *Cupularia* sp. 1 (Bryozoa). Side view showing the dome shaped zoarium. G.S.I., No. 17445.

Fig. 8. *Nephrolepidina sumatrensis* (Brady) G.S.I. No. 17447.

Fig. 9a. *Nephrolepidina chavarana* sp. nov. side view. G.S.I. Type No. 17448.

Fig. 9b. *Nephrolepidina chavarana* sp. nov. Equatorial section (diagrammatic) G.S.I., Type No. 17453.

PLATE 16.

Fig. 10. *Cupularia* sp. 1 (Bryozoa). Zoecia magnified. x 12. G.S.I. No. 17445.

Fig. 11. *Cupularia* sp. 2 (Bryozoa). Zoecia magnified. x 12. G.S.I. No. 17446.

Fig. 12a. *Nephrolepidina chavarana* sp. nov. × 12. G.S.I. Type No. 17448.

Fig. 12b. *Nephrolepidina chavarana* sp. nov. Equatorial section × 24 G.S.I. Type No. 17454.

Fig. 13. *Operculina granulosa* Leymerie × 12. G.S.I. No. 17442.

Fig. 14. *Operculina bartschi* Cushman × 12. G.S.I. No. 17443.

Fig. 15. *Operculina malabarica* sp. nov. × 12. G.S.I. Type No. 17449.

Fig. 16. *Nephrolepidina sumatrensis* (Brady) × 12. G.S.I. No. 17447.

Fig. 17a. *Operculinella lawrieana* sp. nov. × 12. G.S.I. Type No. 17441.

FIG. 17b. *Operculinella lawrieana* sp. nov. Equatorial section × 12. G.S.I. Type No. 17450.

FIGS. 18 & 19. *Operculinella venosa* (Ficht and Moll) × 12. G.S.I. Nos. 17451, 17452.

MISCELLANEOUS NOTES

Geological Notes on Central Nepal

During the course of an investigation of hydro-electric projects in Central Nepal, it was possible to determine certain details regarding the stratigraphy and structure of the area in maps 72 A/E. Details concerning the projects, and the composition of the limestones and iron-ores, are given in pages 132, 237-240 and 263-264 of the General Report for the year 1949. For the Gandak area in map 72A we were fortunate to obtain two strips of air photographs on the scale of approximately 1·8 inch to a mile, from which a sketch map was prepared as a basis for a geological map. This map contains distortions inevitable from tracing from air photographs without ground control, but is only intended to be of a reconnaissance nature. The two areas visited were:—

(*a*) in the neighbourhood of the confluence of the Seti, Marsyandi and Kali Gandaki rivers between north-south grid co-ordinates pO 23870 and pP 24100 and east-west co-ordinates pO pP 12170-12330 of the ¼ inch reconnaissance sheet made in 1924-26.

(*b*) in the neighbourhood of Bhimphedi and Katmandu.

The rock formations present in the Gandak area around Narayangarh are as follows:—

——	High Level River Terraces.	Approximate thickness in feet.
Upper Siwalik.	Large-boulder conglomerate (presumed glacial facies)	1500
	Conglomerates with brick-red clays.	1200
	Conglomerates, grey sand-rock, dull-coloured clays.	5000
Middle Siwalik.	Sand-rock with subordinate conglomerates.	
	Sand-rock with nodules of calcified sandstone, and clay-shales.	3000
Nahan.	Sandstones, marls, clay-shales and pene-contemporaneous conglomerates.	6000
	(Base not seen)	16,700
? Krol-Deoban.	Dolomitic series	
? Pre-Krol.	Banded series: phyllites, quartzites, thin-bedded dolomites and haematite.	

The haematite bands have 57 per cent. of total iron and less than 0 02 per cent. of phosphorus. The siliceous dolomite of the Marsyandi river has 54 per cent. of silica, 24 per cent. of calcium carbonate and 21 per cent. of magnesium carbonate. It is a massive rock which would be very suitable for concrete aggregate in the event of any dam being constructed across the Marsyandi at co-ordinates 27° 48′:84° 26′ (grid co-ordinates 2401:1230).

It is difficult to draw any boundaries between the Lower, Middle and Upper Siwaliks on account of the gradational nature of the formations. The Nahans are typical of those which extend from the Punjab as far east as Barahakshetra (26°53′. 87°10′) (Auden 1946), and the upper formations can also be matched almost anywhere west of Nepal. The main point of interest is in the zone of the large-boulder conglomerates lying at the top of the succession and dipping steeply below the northern outcrop of Nahans on the Kali Gandaki river near 2393:1227. This zone is quite unlike the normal rounded boulder conglomerate of the Siwaliks and may represent a glacial facies of Middle Pleistocene age.

Of interest also are the wide-spread and striking terraces of horizontal high-level river gravels which occur especially along the Kali Gandaki river and to a level of about 600 feet above the present river level.

These rocks are arranged in the following sequence from north to south.

North	Banded Phyllitic Group, with northerly dips.	
	- - - - - - - - - - - - - - - - -	*thrust*
	Dolomite Group, with northerly dips.	
	- - - - - - - - - - - - - - - - -	*thrust* (*Main Boundary Fault*)
	Northern Nahan Group; mainly with northerly dips, but some southerly dips also observed on Kali Gandaki.	
	- - - - - - - - - - - - - - - - -	*thrust*
	Large-boulder Conglomerate.	
	Upper Middle } normal Siwaliks Lower	
	Folded into an anticline with east pitch; faulting west of Narayangarh.	
South		

The main boundary thrust has been traced for 12 miles from grid co-ordinates 2388:1229 on the Kali Gandaki, to 2410:1224 in the hills E. S. E. of the Marsyandi river, where it shows up well in the aerial photographs. The main Siwalik succession, south of the northern Nahan zone, is anticlinally disposed, with an east pitch and bounded on the south side by a concealed fault. The swing round of dips is very well observed on the north-south reach of the main Gandaki river 2 miles upstream of Narayangarh.

In the Bhimphedi-Kulikhani area (72 E) the observations made by one of us (Auden 1935, p. 139) were extended, with more detailed mapping based on the tunnel map prepared by the Nepal authorities. The granite which crops out between Kulikhani (27°35′:85°9′) and the Sisagarhi pass is evidently widespread on the Mahabharat Lekh, even if it does not form a continuous outcrop. Large boulders of this granite are seen in the Dharsing *nala* at the ropeway (27°32′:85°6′), and a porphyritic granite is plentiful as boulders in the Kaliktar *nala* where it joins the Rapti at Bhainse Dobhan (27°30′:85°3′). The sedimentary series of this area consists of a complex assemblage of quartzites, phyllites and impure limestones. The Sisagarhi ridge represents a flat anticline with easterly pitch, south of which lies the Bhimphedi syncline and another anticline. Of interest in this area is the close connection which exists between the metamorphism of the sedimentary series and the Kulikhani granite. This metamorphism can be seen to increase rapidly westwards along the strike of the same series as the granite is approached, and at Kulikhani itself the rocks consist of meso-grade quartz-biotite-granulites and mica-schists. Kyanite-schist, garnet-biotite-schist and highly contorted calciphyres occur in the Kaliktar *nala* at Bhainse Dobhan. This relationship between granite intrusion and metamorphism is comparable with what is found in the neighbourhood of the granites at Lansdowne and Dudatoli in the Kumaon (Middlemiss 1887 ; Auden 1937) and of Chor (West 1928) in Himachal Pradesh.

Auden J. B. (1935) . . Traverses in the Himalaya. *Rec. Geol. Surv. Ind.*, 69, pp. 123—167.

„ (1937) . . . The Structure of the Garhwal Himalaya. *Rec. Geol. Surv. Ind.*, 71, p. 428.

„ (1946) . . . Geological Reconnaissance Reports of the Kosi Dam-Site. Govt. of India, Central Waterways, Irrigation and Navigation Commission. Preliminary Project Report.

„ (1946) . . . Blaini-Talchir. *Current Science*, 15, pp. 346-348.

Medlicott H. B. (1875) Note on the Geology of Nepal. *Rec. Geol. Surv. Ind.*, 8.

Middlemiss, C. S. (1887) . . Physical Geology of Garhwal. *Rec. Geol. Surv. Ind.*, 20, Map p. 40, p. 137

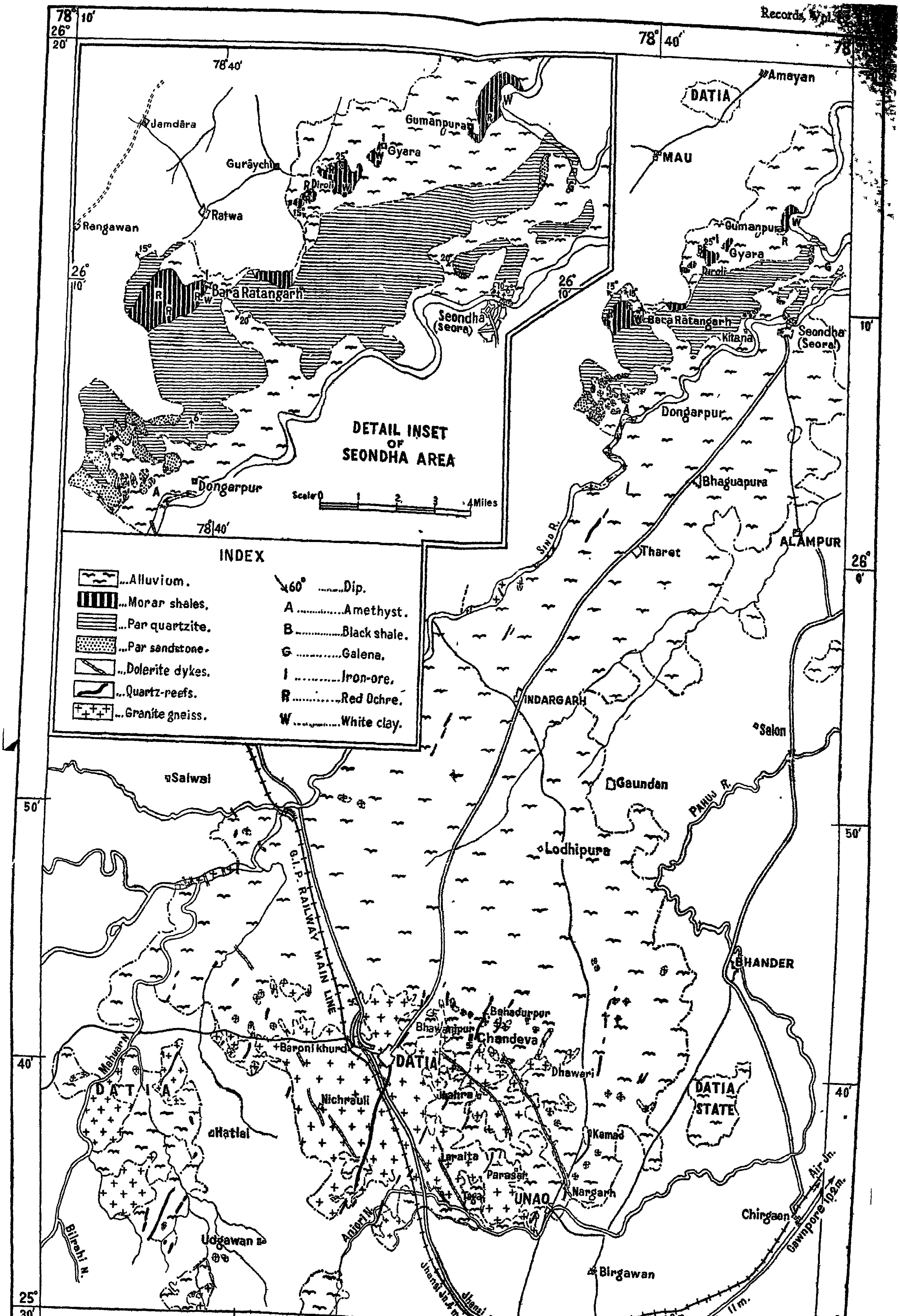
Pilgrim, G. E. (1928) . . The Structure and Correlation of the
West, W. D. Simla Rocks. *Mem. Geol. Surv. Ind.*, 53, p. 65.

West, W. D. (1950) . . . General Report for the year 1949. *Rec. Geol. Surv. Ind.*, 83, Pt. 1.

March, 1949.

J. B. AUDEN.
A. K. SAHA.

MGIPC—S5—11 GSI—20-3-53—1,030.



GEOLOGICAL MAP OF THE DATIA STATE, VINDHYA PRADESH
(SHOWING MINERALS OF ECONOMIC IMPORTANCE)

By
M. K. ROY CHOWDHURY

Scale 5 4 3 2 1 0 5 10 Miles

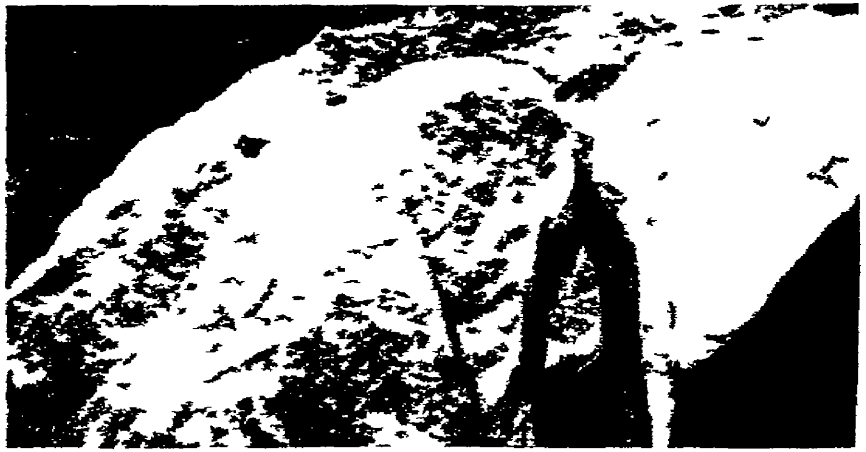


FIG 1

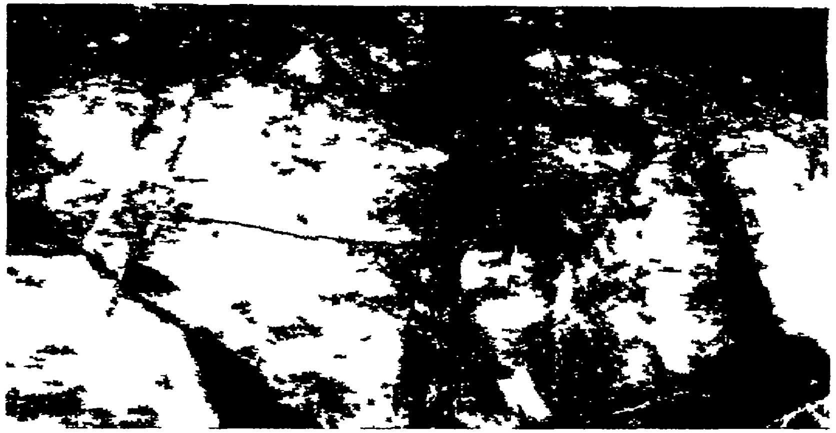


FIG 2

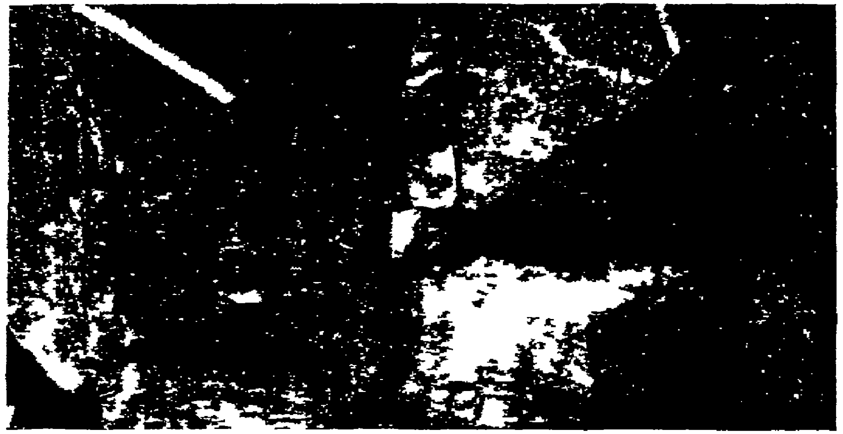


FIG. 3

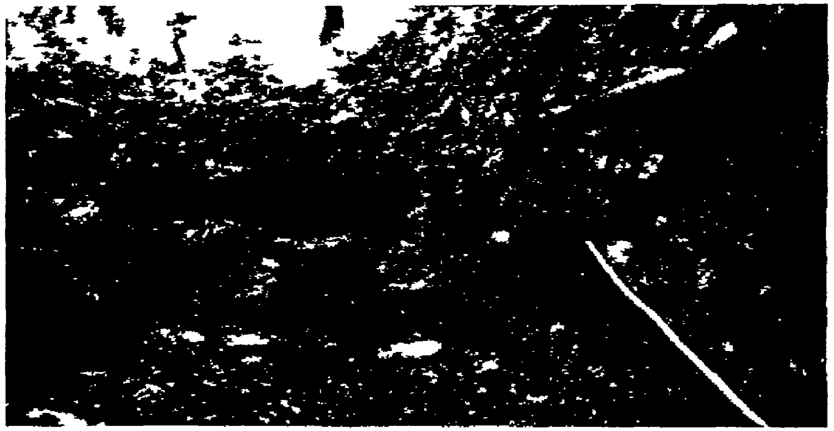


FIG. 4

A M N Ghosh Photos

G S I Calcutta

FIG 5

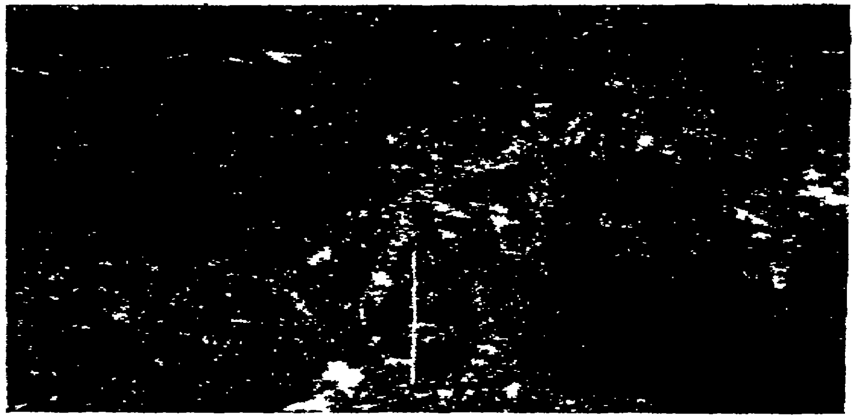


FIG. 6

FIG 7

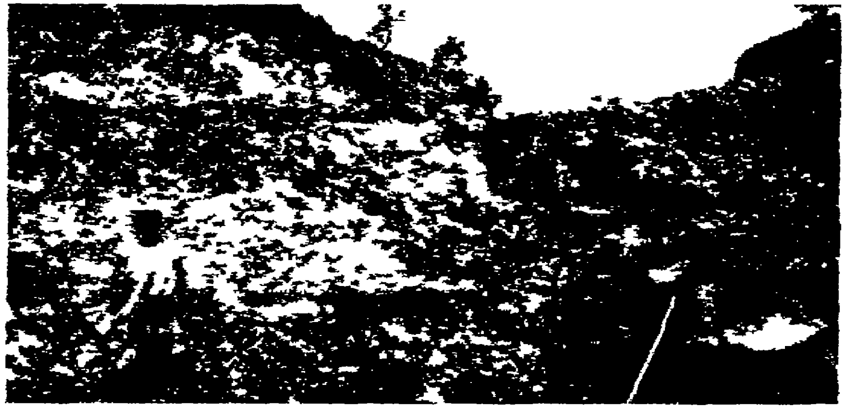
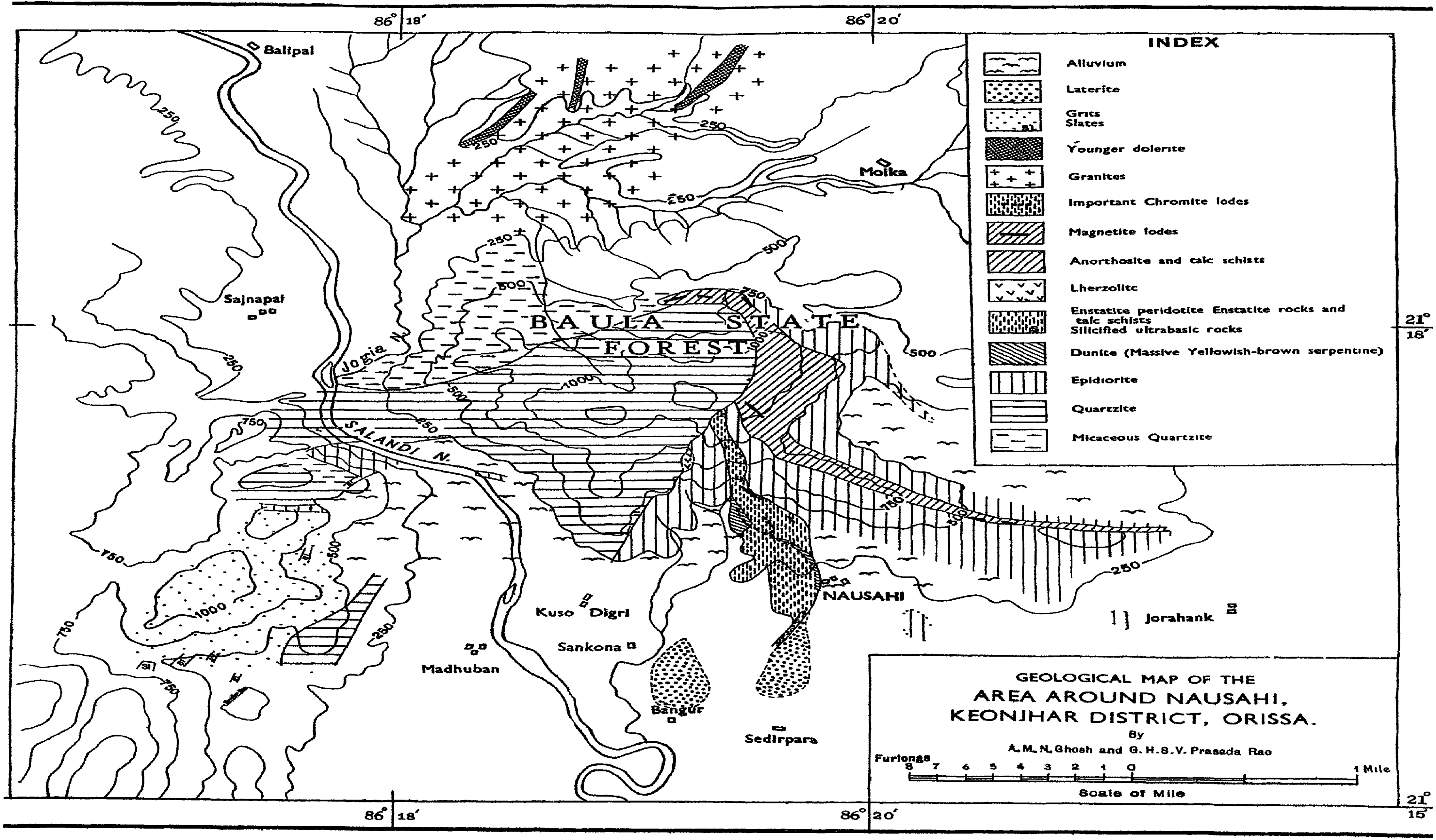
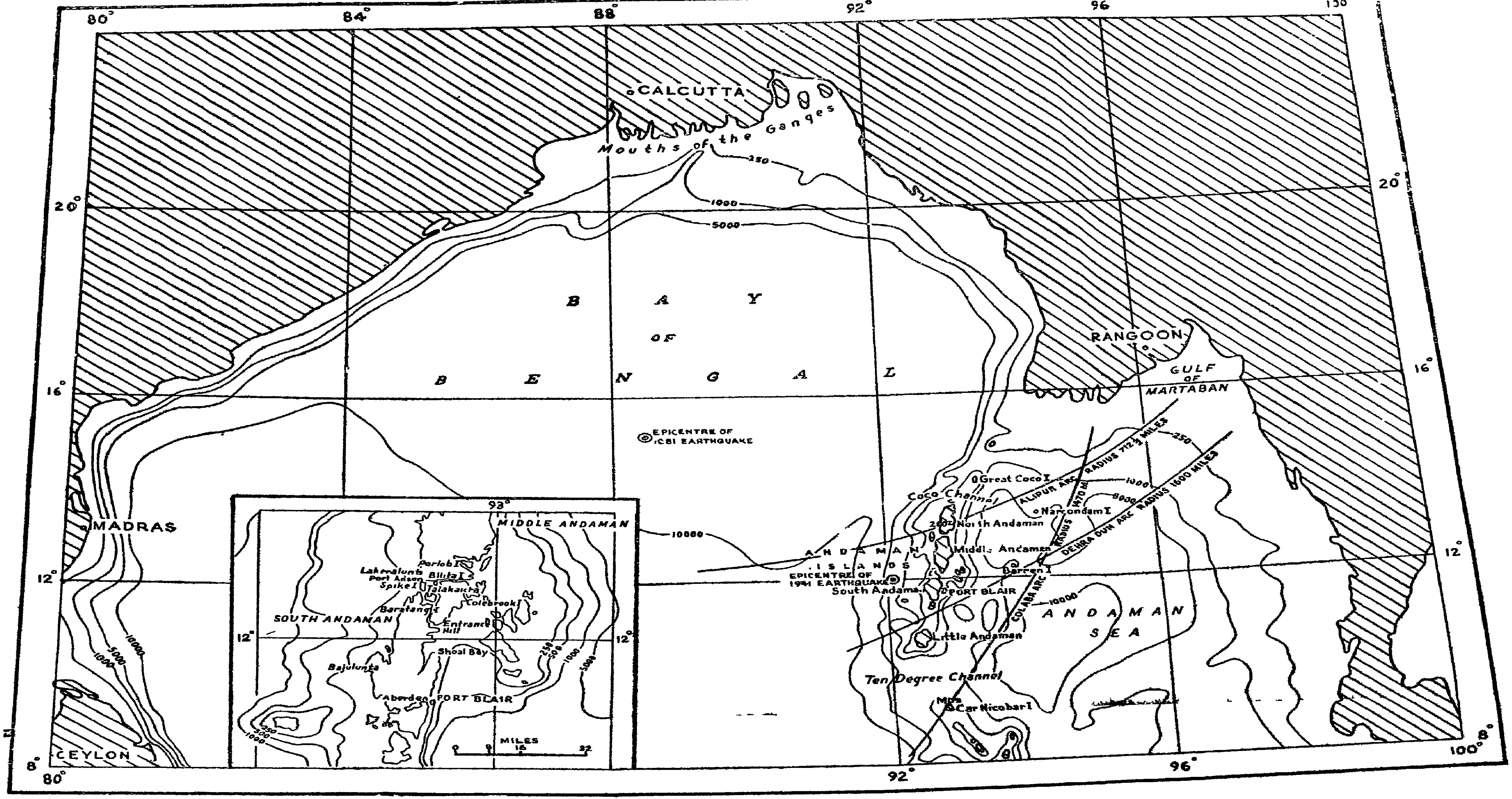


FIG. 8

A M N Ghosh Photos *G S I Calcutta*



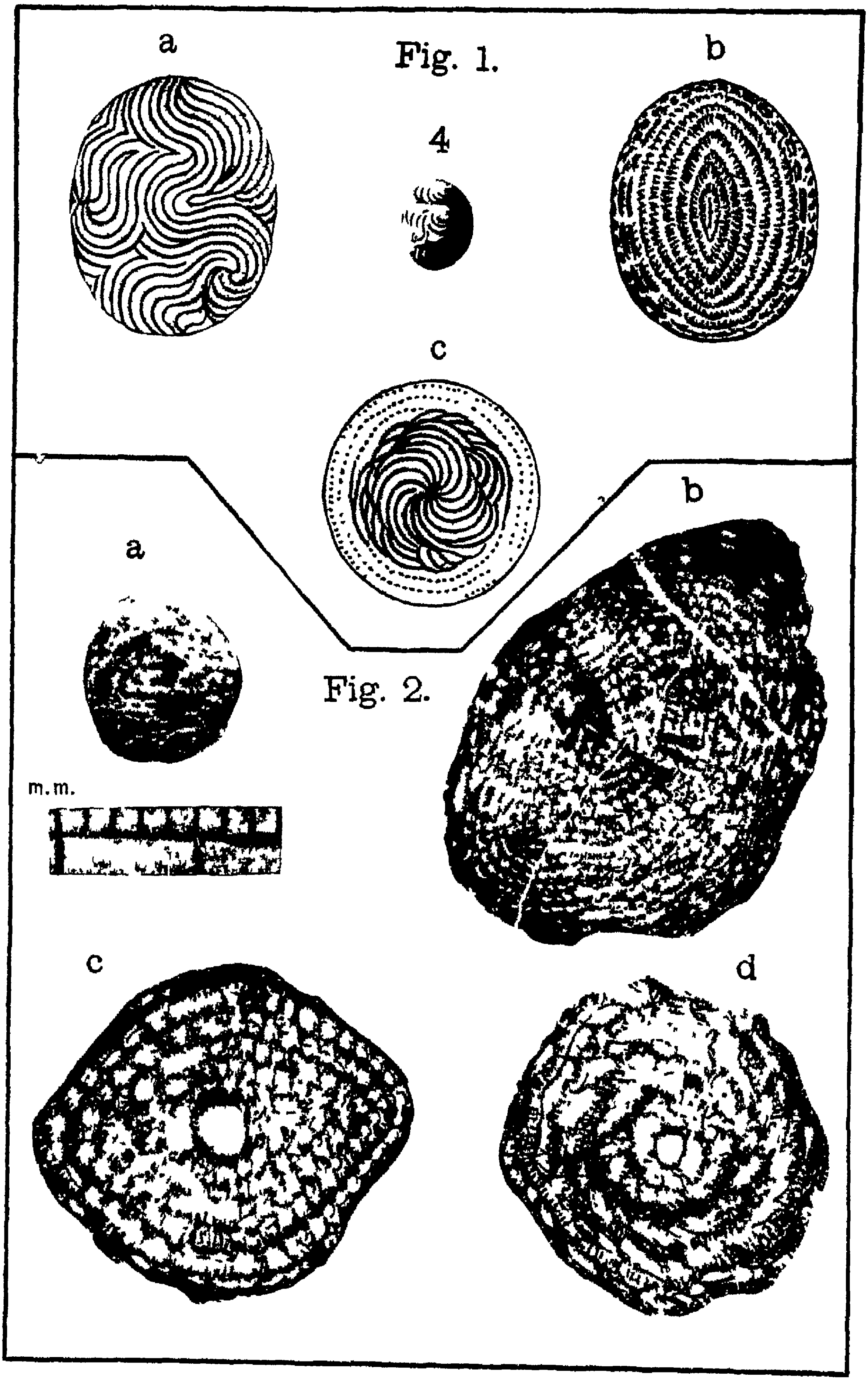
GEOLOGICAL MAP OF THE
AREA AROUND NAUSAHI,
KEONJHAR DISTRICT, ORISSA.
By
A. M. N. Ghosh and G. H. S. V. Prasada Rao



MAP OF BAY OF BENGAL

SHOWING THE EPICENTRE AND OTHER DETAILS OF 1941 EARTHQUAKE

SCALE 100 50 0 100 200 300 MILES



N A Vemban Photo

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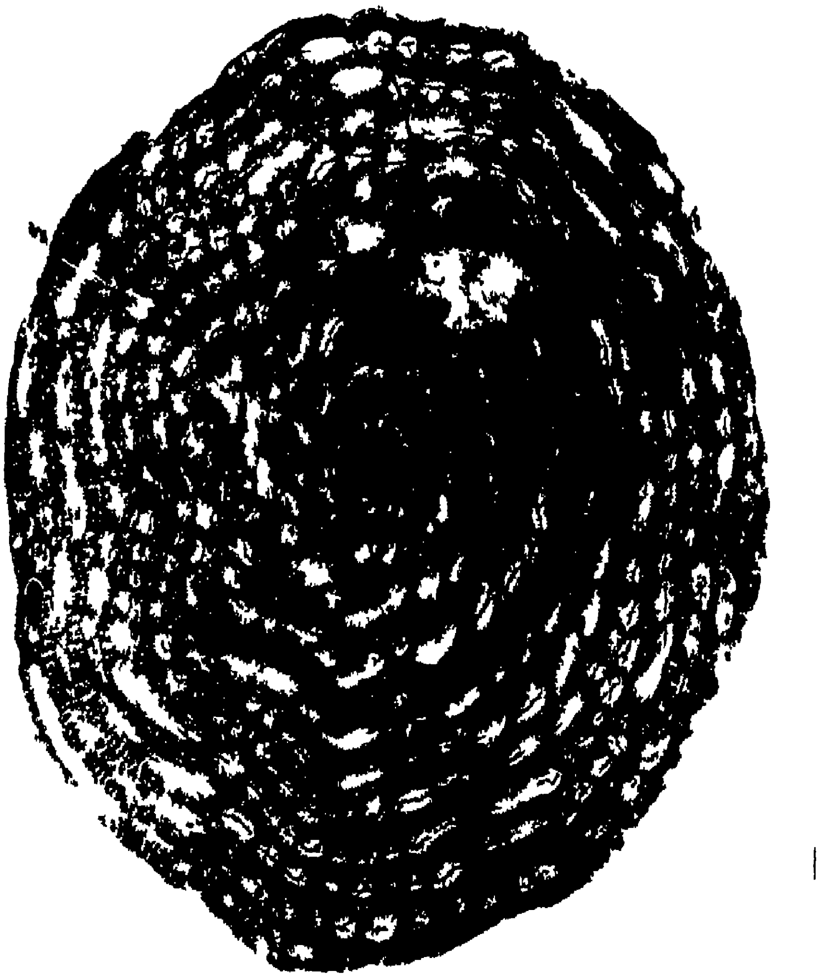

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Fig. 1.

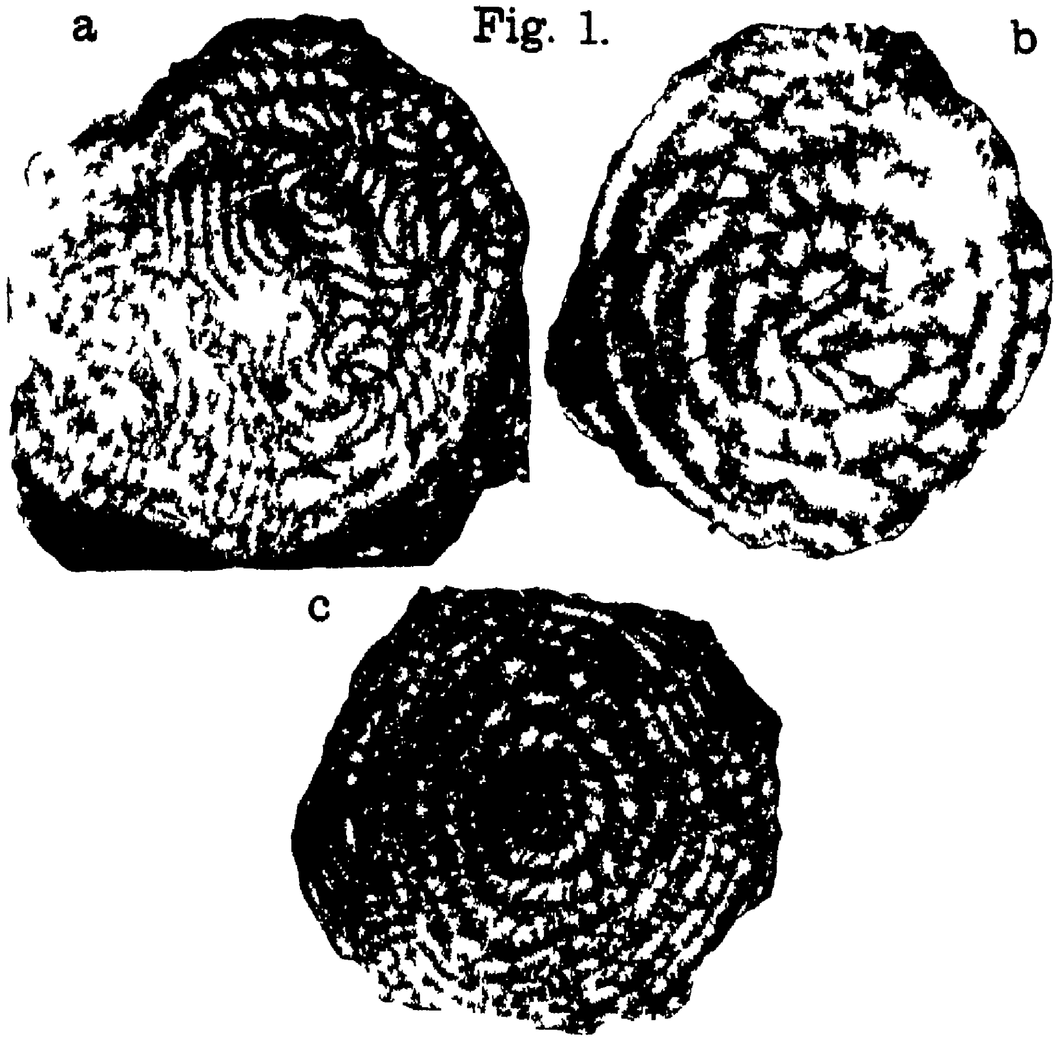
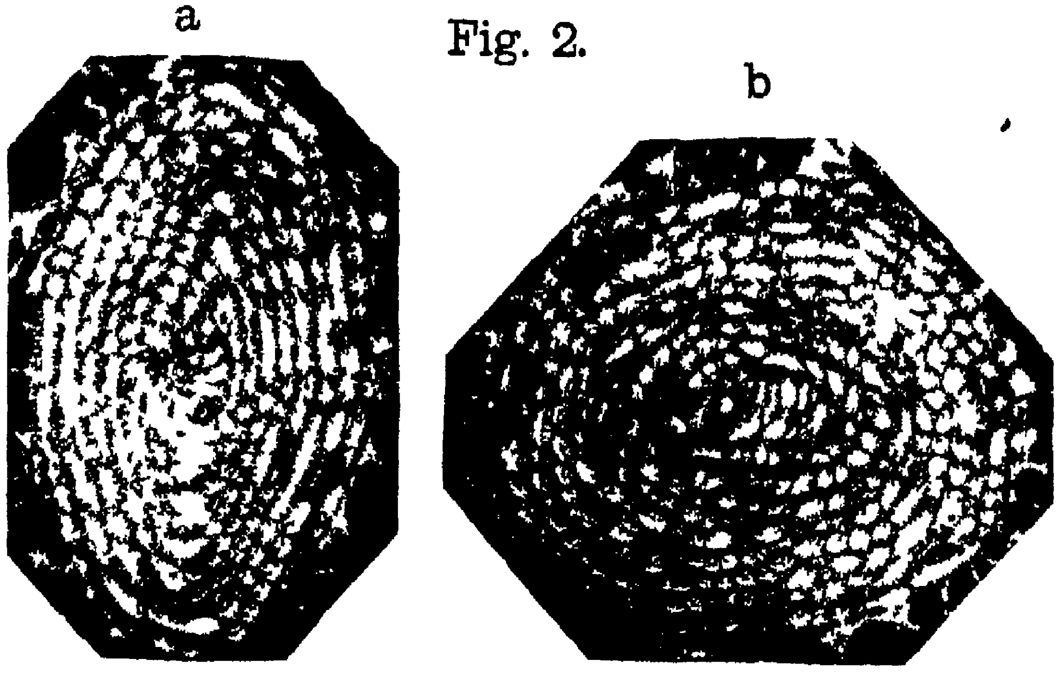


Fig. 2.



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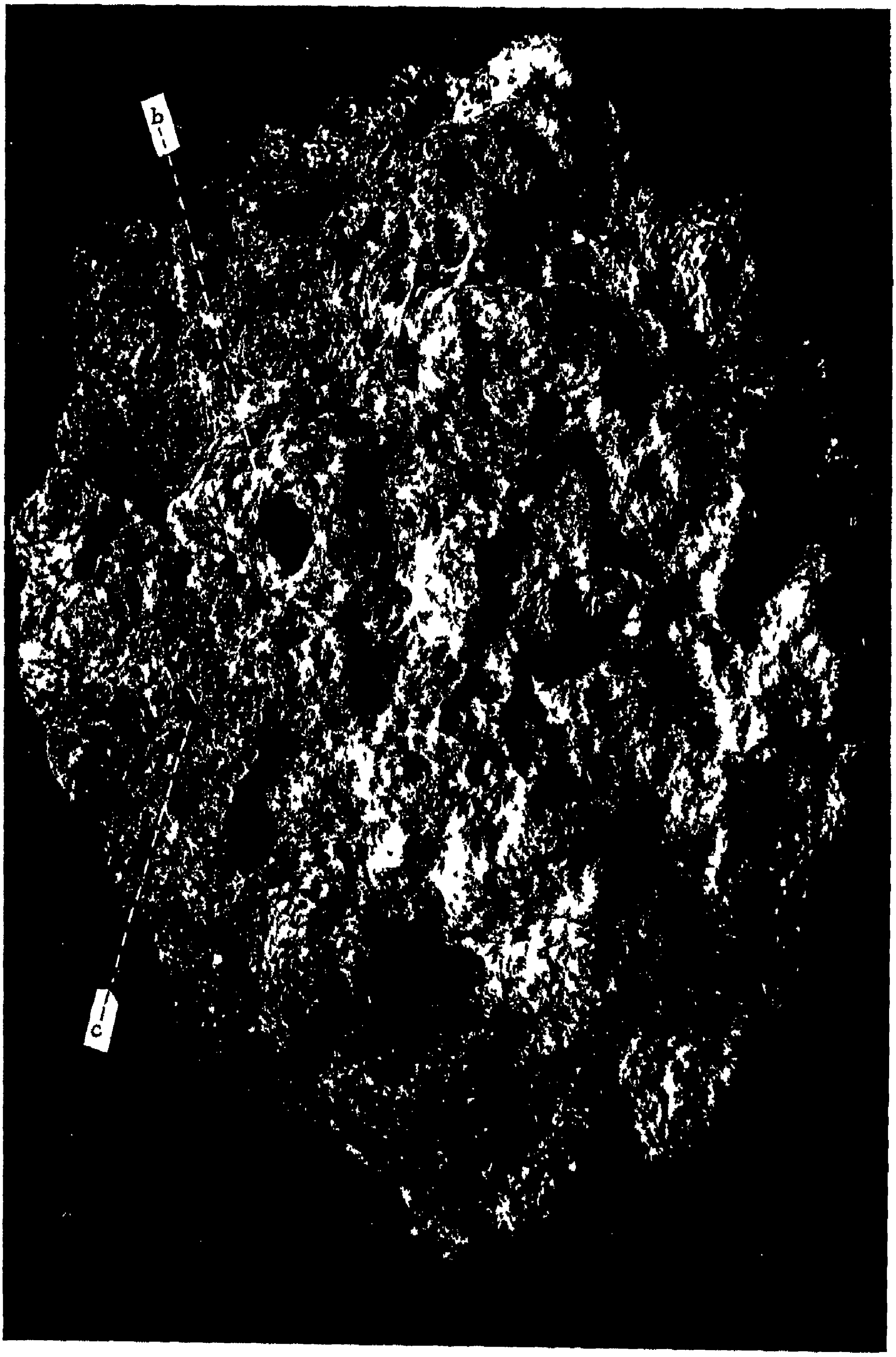

FIG 1. ×ca 04

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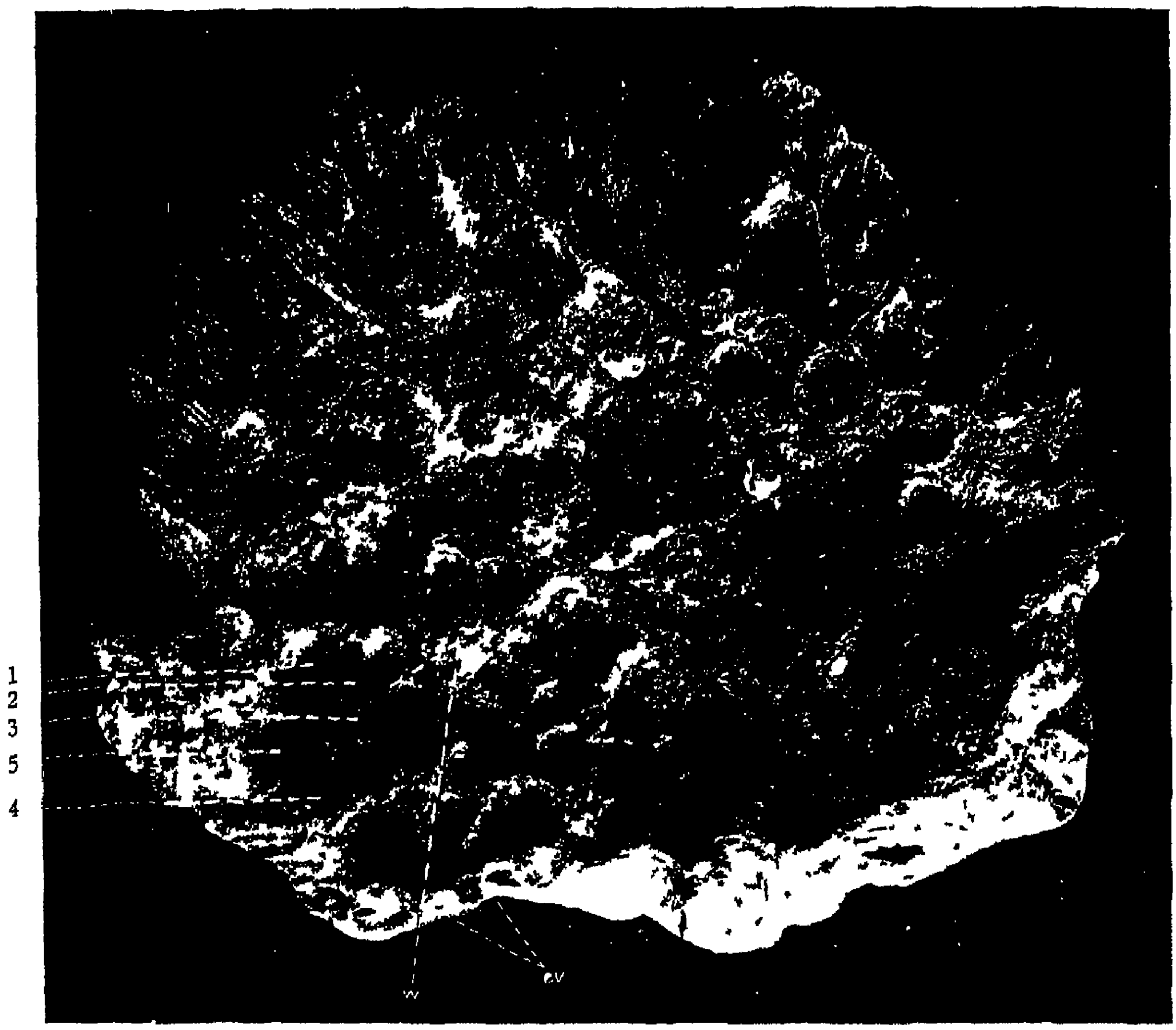

FIG. 2 ×ca 0 3

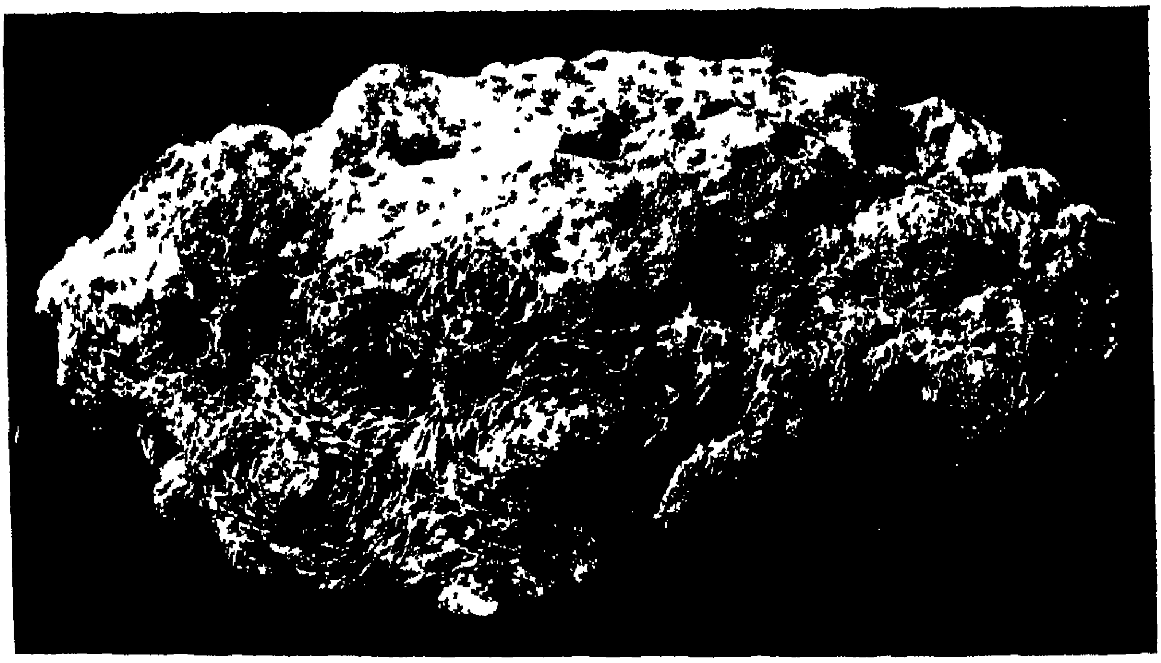

FIG 3 ×ca 0·3

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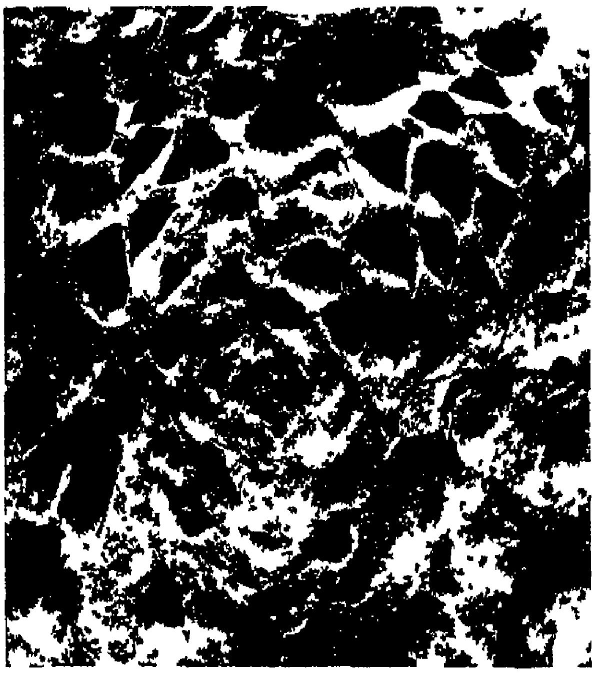

Fig 4 × ca 1·5

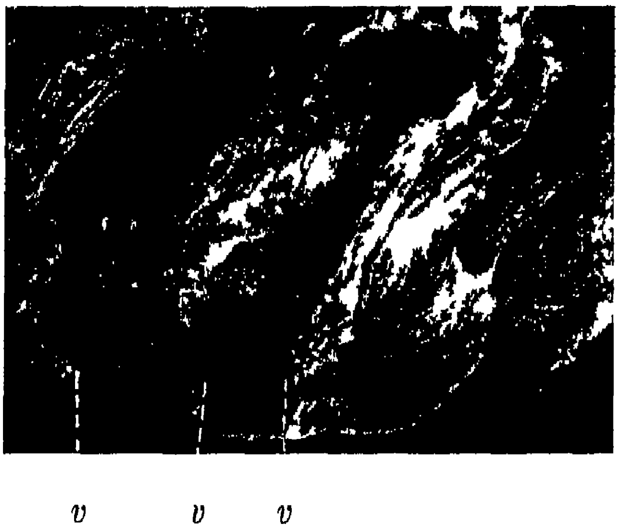

Fig. 6. × ca 0 9

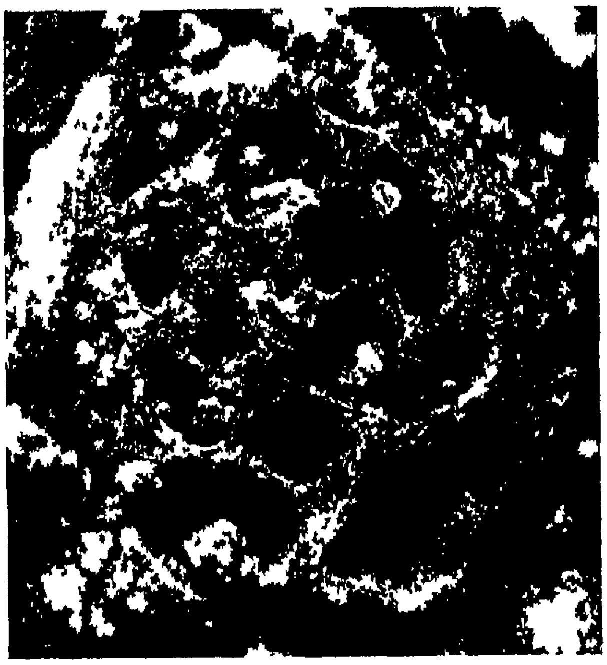

Fig. 5. × ca 5 4

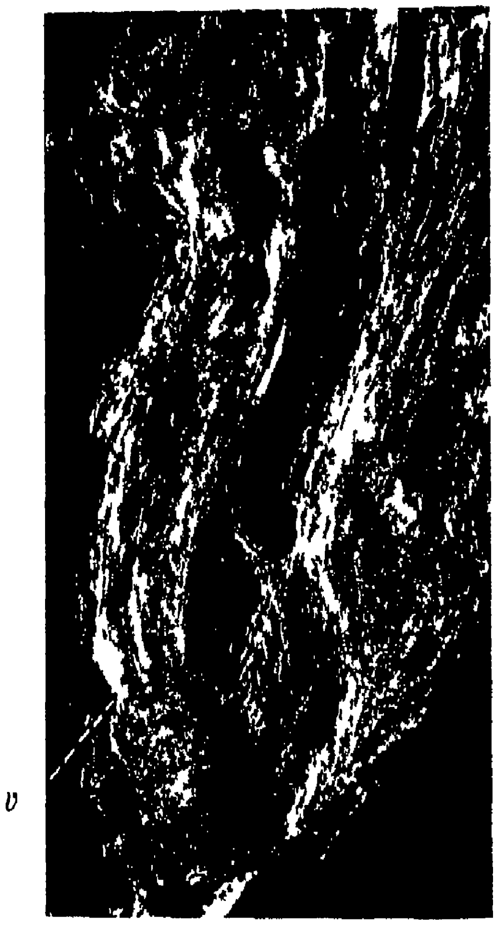

Fig. 7. × ca. 1·4

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CHART SHOWING THE DISTRIBUTION OF FORAMINIFERA, OSTRACODA AND BRYOZOA IN THE CORE SAMPLES

EPONIDES sp.	GYPSINA GLOBULUS (Reuss)	LAGENA STRIATA (d'Orb.)	LEPIDOCYCLINA sp.	NEPHROLEPIDINA CHAVARANA sp. nov.	„ cf MARGINATA (Mich.)	„ SUMATRENSIS (Brady)	NONION SCAPHA (Ficht. & Moll)	OPERCULINA BARTSCHI Cush.	„ GRANULOSA Leym.	„ MALABARICA sp. nov.	OPERCULINELLA LAWRIEANA sp. nov.	„ VENOSA (Ficht. & Moll)	PYRGO BULLOIDES (d'Orb.)	QUINQUELOCULINA BICORNIS (Walk. & Jacob)	„ sp.	REUSSELLA SPINULOSA (Reuss)	ROTALIA sp.	SPIROLOCULINA sp.	TEXTULARIA sp.	BAIRDIA AMYGDALOIDES Brady	„ cf. FOVEOLATA Brady	? CYTHERELLA sp.	LOXOCONCHA sp.	CUPULARIA sp. 1.	„ sp. 2.
			X	●	X	X																			
					●					O	X														
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G.S.I. Calcutta

● = RARE (I SPECIMEN)

X = COMMON (2-6 SPECIMENS)

O = VERY COMMON (7-15 SPECIMENS)

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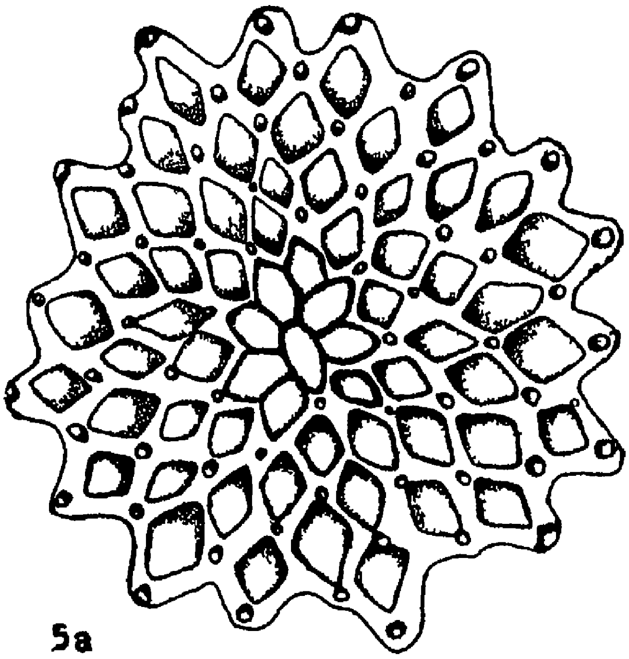

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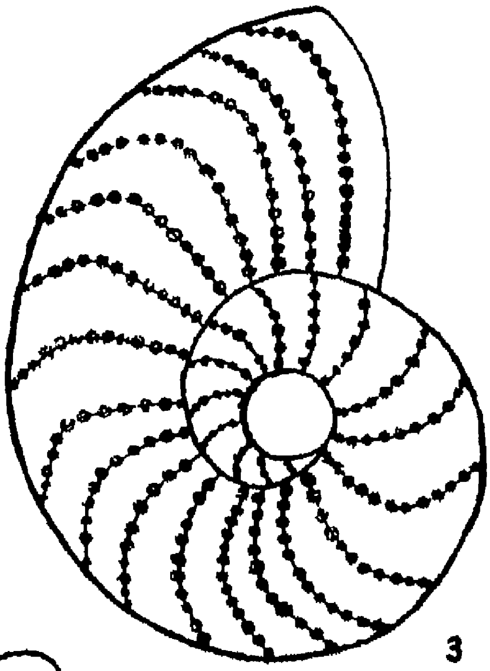

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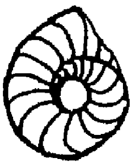

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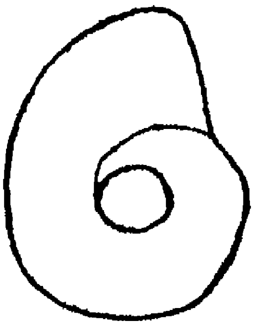

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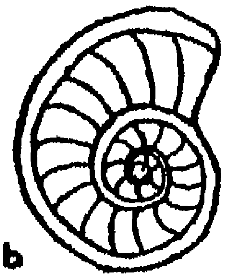

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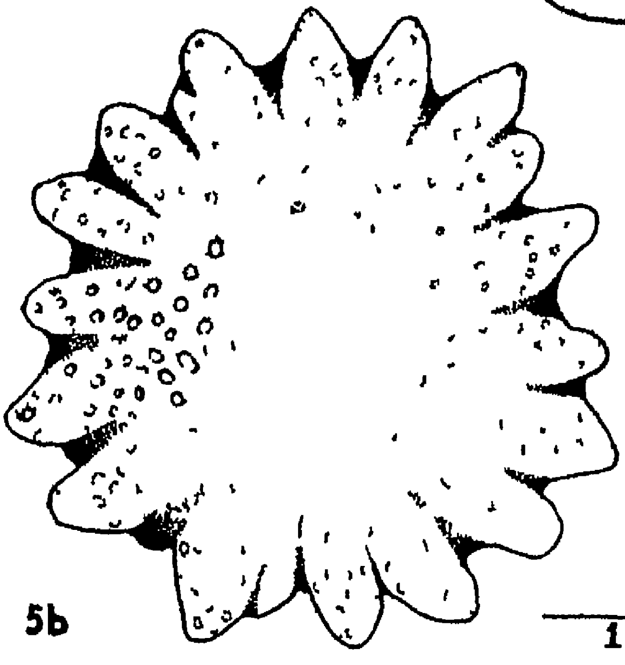

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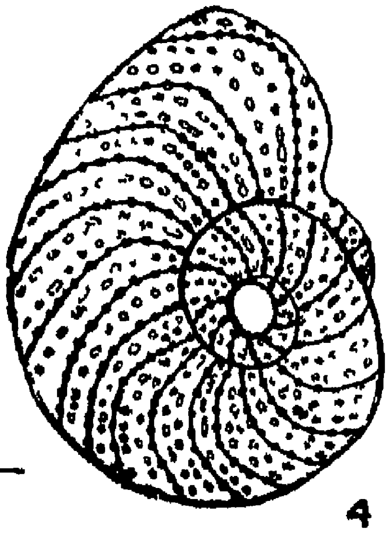

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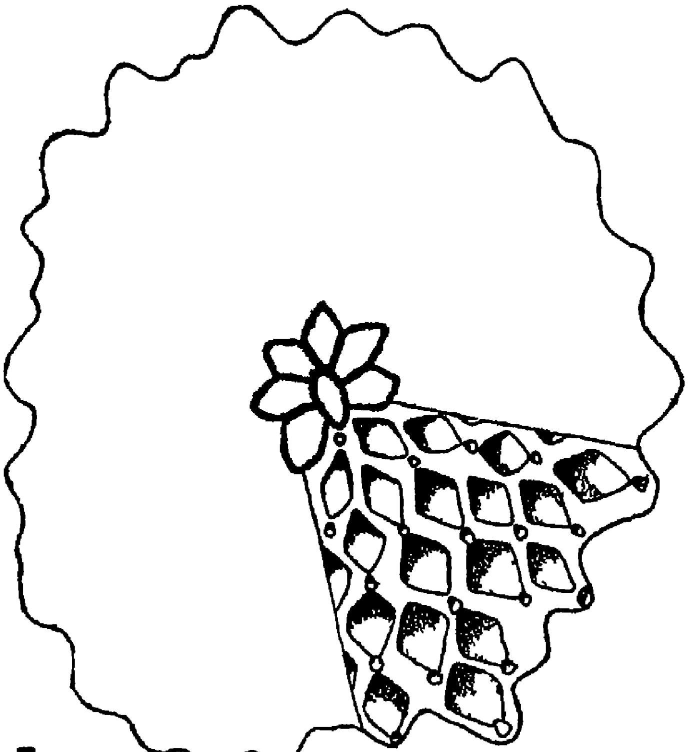

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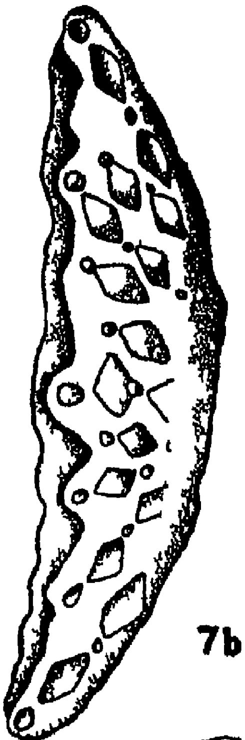

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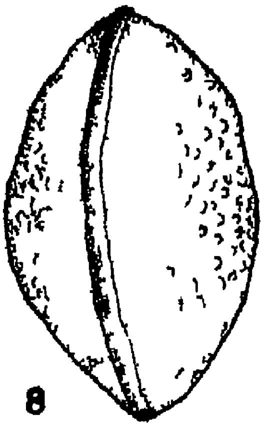

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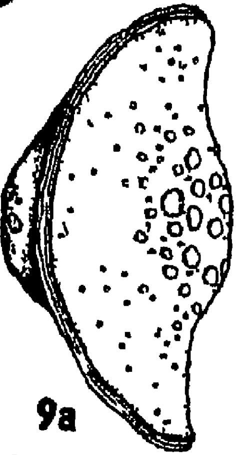

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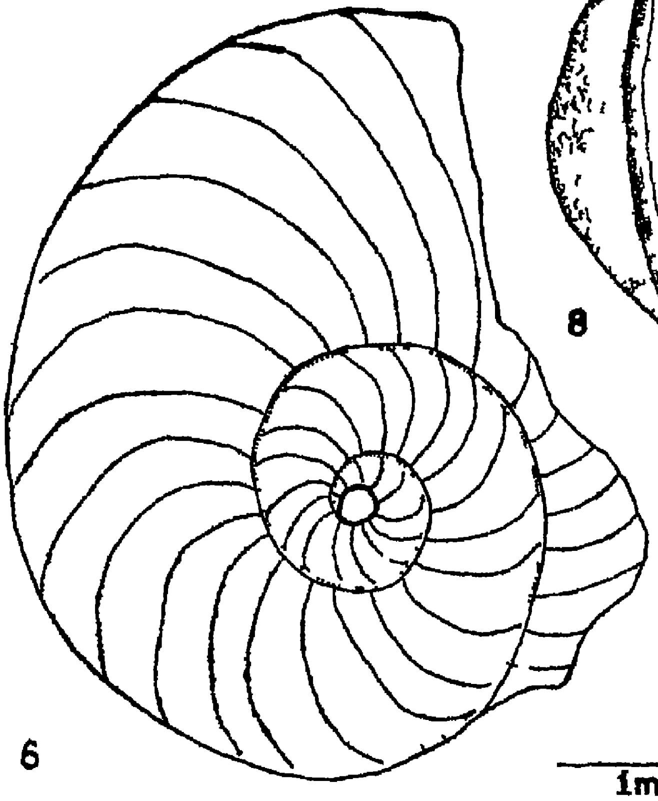

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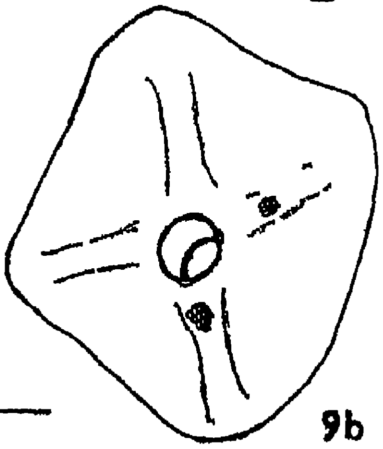

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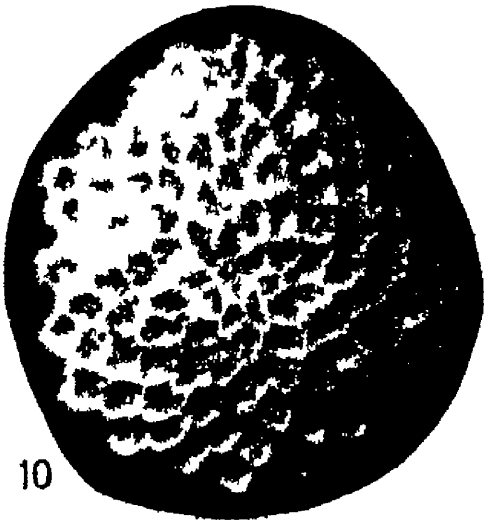
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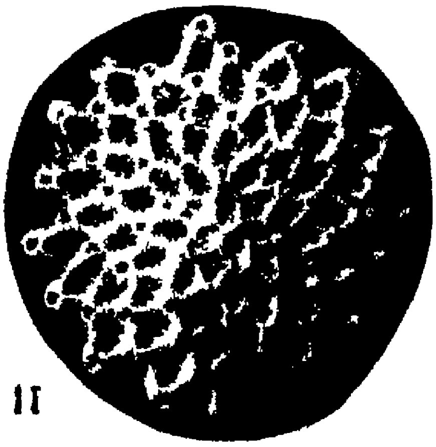
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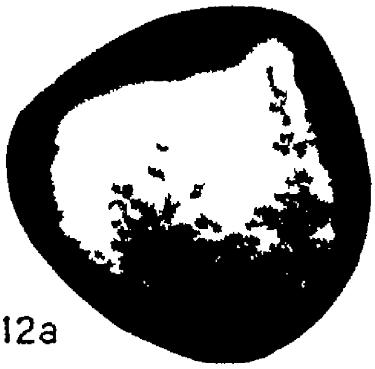
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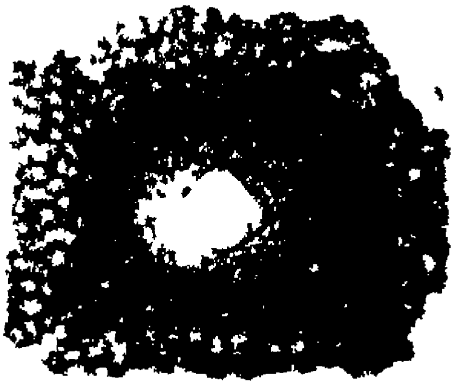
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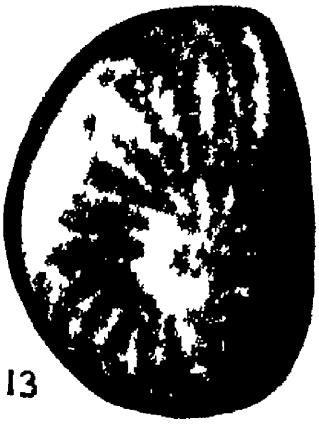
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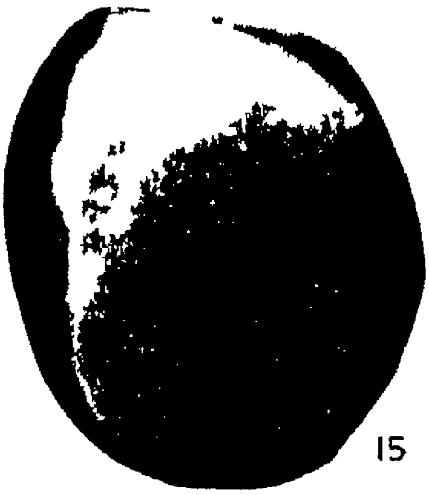
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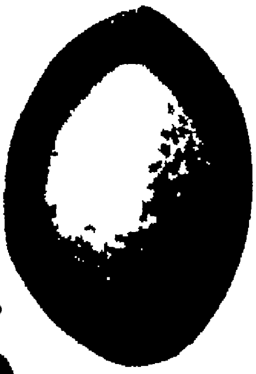
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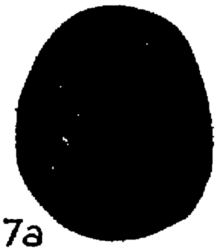
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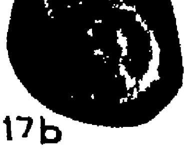
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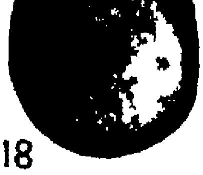
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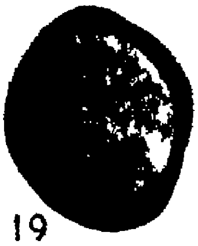
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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA

VOLUME 82] 1952 [Part 3

THE MINERAL PRODUCTION OF THE INDIAN UNION DURING 1948. BY W. D. WEST, C.I.E., SC.D., F.N.I., *Director, Geological Survey of India.*

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INTRODUCTION

This review seeks to present a comprehensive picture of the mineral trade and industry of the country during the year 1948 by giving interesting and useful data in regard to the minerals, and mineral products produced in this year.

The first part of the review deals with the statistics of production and value of these materials. * It contains short notes on each mineral with the relative statistical tables appended thereto and has been prepared by the statistical section of the Geological Survey of India under the supervision of

Mr. R. N. Chakrabarty. Generally, for most of the minerals produced, the following points have been briefly discussed as far as information on them is available with this Department.

1. The uses, treatment, average annual world production.
2. Indian occurrences, reserves, quality or grade.
3. Production in the year under review—comparison with that of the previous year with special reference to increase, decrease, or absence of production in certain areas.
4. Exports of indigenous production—whether wholly or in part, and the reasons therefor.
5. Imports due to deficiency in resources or undeveloped condition of the allied industries.
6. Consumption in Indian industries—possibilities of its increasing use with the growth of those industries.
7. Future prospects.

It will be seen from the statistics compiled that there was an appreciable increase in the output of fire-clay, corundum, diamonds, fuller's earth, graphite, gypsum, manganese-ore, mica and salt, and that the rise in the production of apatite and bauxite was not negligible. The output of these latter minerals, as well as fire-clay and manganese-ore, has been on the increase since 1945. The figures for asbestos, chromite, china-clay, felspar and ochre register a sharp decline in their production and those for bentonite, ilmenite, iron-ore, kyanite, magnesite, and rutile indicate a slight fall. The output of coal, copper-ore, petroleum, and sillimanite, remains more or less the same as in 1947.

With regard to metals, there was some increase in the production of aluminium, gold and silver and an appreciable increase in that of lead. In the case of copper, pig-iron, steel and ferro-manganese, there was a drop in production, that of ferro-manganese being considerable. The total value of minerals produced in the Indian Union during the year 1948 was over Rs. 70 crores against Rs. 64 crores for the year 1947, and the total value of metals manufactured during this year was of the order of Rs. 40 crores against Rs. 31 crores for the year 1947. The details of these values figures are given in tables 1 and 2. This large increase however was mainly due to the increased value of the minerals and metals, the increase in actual tonnage produced being very much less.

TABLE 1.—*Total value of minerals and ores for which returns of production in the Indian Union are available for the years 1947 and 1948.*

Minerals, Ores, etc.	1947	1948
	Rs.	Rs.
Coal	43,77,20,245	45,20,56,474
Gold (*a*)	4,89,54,639	5,43,20,157
Mica	4,65,89,163(*b*)	6,14,40,100(*b*)
Building Materials	3,58,14,385	3,16,27,820
Salt	2,46,89,794	4,33,88,667
Petroleum	1,08,30,060	1,08,99,126
Manganese-ore	96,40,563(*c*)	1,78,49,256(*c*)
Iron-ore	80,67,805	1,02,99,463
Copper-ore	60,35,118	80,44,332
Ilmenite	31,59,271	31,36,697
China clay	14,62,994	11,11,048
Chromite	9,97,639	7,05,963
Steatite	10,02,819	12,05.582
Magnesite	6,86,956	6,61,015
Saltpetre	6,34,960(*b*)	11,31,622
Kyanite	5,99,282	5,68,182
Other clays	6,54,950	5,34.964
Fire clay	6,95,432	8,65,405
Lead (Metal) (*d*)	4,25,470(e)	7,04,600
Barytes	3,29,557	3,59,929
Gypsum	4,66,283	7,98,261
Ochre	2,00 153	2,86,809
Emerald	..	2,51,884
Graphite	1,55,317	2,64.349
Bauxite	1,48 316	1.76,451
Diamond	1,72,652	4,17,373
Silver (*f*)	54.725	60,299
Rutile	30,868	24,925
Fuller's earth	29,104	1,72,776

TABLE 1—(*contd.*)

Minerals, Ores, etc.	1947	1948
	Rs.	Rs.
Calcite	20,543	4,043
Sillimanite (Sand)	20,299	16,007
Felspar	16,874	10,466
Corundum	48,760	31,090
Asbestos	15,394	8,819
Apatite	8,533	15,410
Quartzite	6,603	480
Bentonite	3,550	1,100
Quartz-Mica-Schist	1,860	..
Garnet Sand	800	..
TOTAL	64,03,91,732	70,34,50,894

(*a*) Value of gold metal is given in the absence of the value of gold ore.
(*b*) Value of exports.
(*c*) F.o.b. value at Indian ports.
(*d*) The value of lead metal is given in the absence of the value of lead ore.
(*e*) Includes the value of 7 tons of lead ore.
(*f*) Value of silver metal is given as no silver ore is produced in India.

TABLE 2.—*Total value of metals produced in the Indian Union during the years 1947 and 1948.*

Metals.	1947	1948
	Rs.	Rs.
Steel	21,28,23,450	29,43,86,875
Gold	4,89,54,639	5,43,20,167
Pig iron	2,75,88,470(*a*)	3,10,69,030(*a*)
Copper	88,31,259	99,67,100
Aluminium	60,91,470	68,37,040
Ferro-Manganese	57,18,075	41,13,000
Lead	4,23,720	7,04,600
Silver	54,725	60,299
TOTAL	31,04,85,808	40,14,58,101

(*a*) Value of pig iron left after consumption in steel making.

Table 3 shows the figures of production, export, import, and the total quantities available for consumption, of important minerals and mineral products, during the calendar year 1948. The consumption figures have been arrived at by adding the retained import figures to and deducting the export figures from the production figures. These figures are intended to give an idea of the estimated consumption of these materials in the absence of any reliable data of their actual consumption. A similar table did not appear in the Mineral Production of the Indian Union during 1947 published in Records, Vol. 81, Part 3, as the figures relating to exports and imports on the basis of the Indian Union were not available from the Sea-borne Trade Accounts for 1947. The figures of exports and imports shown in this table have been taken from the Sea-borne Trade Accounts for 1948, which exclude the foreign trade of Pakistan from 1st March, 1948. Therefore, allowing 4 per cent. for Pakistan for two months (on the basis of 20 per cent. for the whole year). more than 95 per cent. of these figures may be reckoned as representing the volume of foreign trade of the Indian Union during the year 1948 in respect of the minerals and mineral products listed in this table. Consequently, the consumption figures may be roughly taken to cover the quantities of these materials available for consumption in India during the same year.

TABLE 3.—*Consumption of ores, minerals and metals in India during 1948.*

Name of ores, Minerals and metals	Unit.	Production.	Retained import.	Export of domestic production.	Available for consumption.
Aluminium (Unwrought) .	Tons	3,368	830 (Unwrought) 9,299 (Wrought)	..	13,497
Aluminium Ore (Bauxite) .	,,	22,156	..	535	21,621
Arsenic	,,	..	135	..	135
Asbestos	,,	82	3,644	..	3,726
Barytes	,,	23,143	11	15,181	7,973
Bentonite	,,	160	..	..	160
Borax . . .	Cwts.	(*b*)	62,280	..	..
Brass, Bronze, etc. . .	Tons	9,553	Unwrought 40 wrought 4,650	..	14,243
Clay (other) . . .	,,	291,247	..	..	291,247
China clay	,,	41,243	1,510	..	42,753
Chromite	,,	22,555	..	9,250	13,305
Coal	,,	30,124,175	15	934,521	29,189,669

TABLE 3—(*contd.*)

Name of ores, Minerals and metals.	Unit.	Production.	Retained import.	Export of domestic production.	Available for consumption.
Coal Tar and Pitch . .	Tons	65,078	657	.	65,735
Copper (Unwrought) . .	,,	5,863	28,736 (Unwrought) 11,459 (Wrought)	..	46,058
Diamond	Carats.	2,426	(c)	..	2,426
Ferro-Manganese . .	Tons	9,140	..	..	9,140
Felspar	,,	987	..	..	987
Fuller's earth . . .	,,	6,011	..	..	6,011
Gold	Ozs.	180,430	4,330(*d*)	..	184,760
Graphite	Tons	1,649	1,100	..	2,749
Gypsum	,,	78,948	..	..	78,948
Ilmenite	,,	229,416	..	247,221	..
Iron ore	,,	2,284,587	1,519	..	2,286,106
Iron (Pig)	,,	1,455,093	294	39,751	1,415,636
Iron and Steel Materals .	,,	960,419	141,352	10,980	1,090,701
Kyanite	,,	12,605	..	(*a*)	..
Lead ore	,,	8,634	..	..	8,634
Pig Lead	,,	541	8,632	.	9,173
Magnesite	,,	48,327	..	14,171	34,156
Manganese ore . . .	,,	525,876	..	363,482	162,394
Mica	Cwts.	151,273	..	301,875	..
Ochre	Tons	10,557	..	..	10,557
Petroleum, crude . .	Galls.	65,607,982	..	..	65,607,082
Petroleum products . .	,,	54,660,668(*e*)	483,190,924(*f*)	..	537,851,592
Phosphate (Apatite) . .	Tons	1,114	22,194	..	23,308
Potash Saltpetre . .	Cwts.	59,440	..	721	58,719
Quick silver . . .	Lbs.	..	686,126	..	686,126
Rutile	Tons	127	..	.. (*g*)	..
Salt	,,	2,264,536	345,576	8,590	2,601,522
Silver	Ozs.	12,797	4,619,917(*d*)	..	4,632,714
Sillimanite	Tons	213	..	.. (*g*)	..
Steatite	,,	18,096	..	3,683	14,413
Sulphur	Cwts.	..	744,471	..	744,471
Sulphate of Ammonia . .	Tons	36,142	140,009	..	176,151
Tin	Cwts.	..	12,841	..	12,841
Zinc	,,	..	689 311	..	689,311

(*a*) Almost the whole of the output of Kyanite is known to be exported.

(*b*) Known to be produced but the production figures are not available.

(*c*) Quantity not known, the value of diamond imported during 1948 was Rs. 74,07,943.

(*d*) Including coins.

(*e*) Comprising motor spirit, kerosene, distillate fuels, bitumen, sundry oils, coke.

(*f*) Kerosene, fuel oils, lubricating oils and motor spirit.

(*g*) Entirely exported.

Table 4 shows the average number of persons employed daily in 1948 in raising the minerals from the mines in the Indian Union for which reliable statistics of labour are available. The total number of persons so employed was a little more than that in the previous year, being 539,855 against 527,281 in the year 1947. It is to be noted that 95 per cent. of the total number is employed in the mining of coal, mica, manganese and gold and in the manufacture of salt. This fact goes to show the size of these industries at present and the labour figure marked against each of these minerals reveals its relative position in the mineral industry of the country.

TABLE 4.—*Average number of persons employed daily in 1947 and 1948 in the production of minerals from mines in the Indian Union for which reliable labour statistics are available.*

——	1947	1948
Coal	303,994	348,383
Salt	61,614(*a*)	89,440(*a*)
Mica	32,655	32,527
Manganese-ore	19,708	20,171
Gold	19,714	24,579
Iron-ore	15,868	9,550
Petroleum	4,278	4,187
Ilmenite	1,278	1,020
Copper-ore	3,961	3,636
Magnesite	2,383	2,827
Chromite	1,483	1,405
Diamonds	845	2,150
TOTAL	527,281	539,855

(*a*) Estimated.

The second part of the review deals with the statistics of mineral concessions granted and terminated during the year 1948. It contains two tables and one long list of mineral concessions.

Table 1 under Mineral Concessions shows the total number of concessions current in each province at the end of the year 1948. As has already been stated in the Introduction to the Mineral Production of the Indian Union published in Records, Vol. 81, Part 3, this table does not take into account the number of concessions existing, prior to 1st January, 1947, in the States which merged with provinces such as, Bihar, Orissa, C. P., Bombay, Madras. The number of concessions current in the provinces of the Indian Union (excluding the States and States Union) as shown in this table is therefore somewhat less than it actually is.

Table 2 under Mineral Concessions summarises the details of concessions granted and terminated during 1948 in the Indian Union including the provinces with merged States, States Unions and individual States.

The list gives the details of the concessions shown in table 2.

I. ORES, MINERALS, ETC. PRODUCED IN THE INDIAN UNION.

Apatite

An important use of apatite and rock phosphate is for conversion into the fertiliser, superphosphate. A small quantity is absorbed in the manufacture of elemental phosphorus, chemicals and in metallurgy. When used for agricultural purposes, apatite is ground to a fine powder. The average annual world production during the years 1940-46 was a little over 9 million metric tons.

In India a small amount of phosphate is obtained from Trichinopoly in Madras and Singhbhum. The former deposits are of phosphatic nodules and are estimated to contain over 8 million tons of nodules. The latter are of rock phosphates and capable of more vigorous development. However, no production has been reported from Singhbhum area since the year 1938 when a quantity of 400 tons was produced. The output of apatite in the Trichinopoly district, Madras, rose to 1,114 tons valued at Rs. 15,410 in 1948. It was 853 tons valued at Rs. 8,533 in 1947 against 243 tons valued at Rs. 2,430 in 1946. 22,194 tons of phosphatic manures were imported during the year 1948. The quantity of this mineral available for consumption in India during this year was, therefore 23,308 tons (1,114 plus 22,194). Obviously India is deficient in this mineral and requires further investigation of her deposits and their exploitation.

Asbestos

There are two chief commercial varieties of asbestos-chrysotile associated with serpentine and the long fibred but less flexible tremolite type. The chrysotile variety is more valuable. The main uses of asbestos are in asbestos textiles, yarns, cordage and cloth, in paper, compressed sheets, in such cement products as shingles and corrugated sheets, in heat resisting articles, etc. On removal from the mine the longer fibre asbestos is freed from the rock material and then graded by hand according to the length of the fibre. The rest is crushed and the liberated fibres drawn off by an exhaust fan. The average annual world production during the years 1940-46 was about 552,000 metric tons.

India has small resources of asbestos mainly in Madras, Mysore, Bihar, Rajasthan and Ajmer-Merwara. The chief producing areas comprise the Hassan district of Mysore, and the Singhbhum district including the Seraikela sub-division in Bihar and the Cuddapah district of Madras. The first three produce asbestos of the tremolite variety, while the deposits in Cuddapah yield good chrysotile asbestos. In 1948, production was reported from Mysore, Jhabua and Seraikela. The output of Mysore and Seraikela fell to 28 tons and 15 tons respectively from 91 tons and 30 tons during the year 1947, that of Jhabua being of the same quantity as in the earlier year, *vide* table 5. Production of asbestos increased considerably during the war years and attained the peak of 895 tons in 1943. This increase was maintained up to the year 1945, and since then the production declined sharply every year. It was reported by the C. I. M. that the mines in Cuddapah, Singhbhum, and Ajmer-Merwara were not being worked since 1947. Yet the number of mining leases for asbestos reported to have been existing in the year 1948 was twenty of which eleven were held in the district of Cuddapah, two in Ajmer-Merwara and one in the district of Singhbhum. 72,876 cwts. of raw asbestos and a large quantity of manufactured asbestos valued at Rs. 41,15,959 were imported during this year. Apart from manufactured asbestos, the quantity of raw asbestos available for consumption in India during 1943 was therefore 74,516 cwts. (1,640 plus 72,876). India's deficiency in this mineral necessitates intensive development of her existing resources.

TABLE 5.—*Quantity and value of Asbestos production in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons	Rs.	Tons	Rs.
Bihar—				
Seraikela	30	4,650	15	2,325(*a*)
Madhya Bharat (Jhabua) .	39	3,744	39	3,744
Mysore	91	7,000	28	2,750
TOTAL .	160	15,394	82	8,819

(*a*) Estimated.

Barytes

Barytes is very largely used for the preparation of paint, but the inferior qualities have been used from time to time in considerable quantities for increasing the density of drilling muds when boring for petroleum. Apart from handpicking to remove associated rock material, the barite requires to be finely ground before being used in paint or as a filler in other industries. The average annual world production during the years 1940-46 was about one million metric tons.

The production of barytes in India is chiefly reported from the Anantapur, Cuddapah and Kurnool districts in Madras. There has been some output from Alwar also. It is also known to occur in the Manbhum and Singhbhum districts of Bihar and Gangpur in Orissa. In the year 1947 the total output amounted to 24,310 tons valued at Rs. 3,29,557. In 1948 the production came down to 23,143 tons valued at Rs. 3,59,929 the mines in Kurnool, and Anantapur being responsible for this fall, *vide* table 6. Production of barytes in India rose considerably during the last decade and brought down the imports to a negligible quantity. Only 11 tons were imported in the year 1948. India's resources of this mineral are probably adequate to take care of domestic requirements. It is now consumed mainly in the paint and oil industry in India. There is scope for the expansion of the paint industry, and consequent increase in the local demand of this mineral. It is also exported in considerable quantities. 15,181 tons valued at Rs. 18,32,358 were shipped this year.

TABLE 6.—*Quantity and value of Barytes produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons	Rs.	Tons	Rs.
Madras—				
Anantapur	13,539	1,59,340	10,882	1,16,897
Cuddapah	6,131	1,20,697	10,775	2,19,866
Kurnool	4,555	47,820	1,486	23,166
Rajasthan—				
Alwar	85	1,700	..	..
TOTAL .	24,310	3,29,557	23,143	3,59,929

Bauxite

Bauxite is the principal ore for the extraction of aluminium. It is also used for refining kerosene, making refractories, high alumina cement, and for chemicals required in dyeing, tanning and other industries. For the manufacture of chemical products, alumina and aluminium, bauxite passes through a series of complex technical processes; for the manufacture of refractory bricks, and alumina cement, it requires to be ground to size. Roughly 2 tons of bauxite are required to yield 1 ton of alumina and 2 tons of alumina will give 1 ton of metallic aluminium. The average annual world production during the years 1940-46 was about seven million metric tons.

In India deposits of bauxite are widely distributed but occur mainly in Bihar, the Central Provinces, Bombay and Madras. Proved workable occurrences of bauxite are those of the Ranchi district of Bihar, the Jubbulpore and Balaghat districts of the Central Provinces, Khaira, Kolaba, Kolhapur and Belgaum in Bombay and the Shevaroy hills of Salem in Madras. India possesses large resources of bauxite, and this material is in many ways superior to the true bauxite of France for the preparation of alumina. The reserves are roughly estimated at 250 million tons including all grades. High grade reserves are of the order of 35 million tons. The better grade of Indian bauxite contains about 55 per cent. alumina.

The output of bauxite in India rose to 22,156 tons valued at Rs. 1,76,451 from 19,906 tons valued at Rs. 1,58,493 during the year 1947, the mines in Jubbulpore being responsible for this increase, *vide* Table 7. The absence of production from Nagod in Vindhya Pradesh, is reported to have been due to labour and transport difficulties. As stated in the Review of Mineral Production in 1947, the first aluminium ingot was produced in India in 1943, but it was obtained by reducing imported alumina. It is now being produced partly from Indian bauxite. The quantity of aluminium manufactured in India in 1948 amounted to 3,368 tons (or 67,360 cwts.) as against 3.223 tons in 1947. The requirements of alumina for the production of aluminium were provided partly from imports and partly from the manufacture at the plants at Jaykaynagar near Asansol and at Muri in Bihar. The amount of bauxite used in the Asansol plant was 4,781 tons in 1948 against 5,873 tons in 1947. For the first time in the Muri plant a quantity of 2,960 tons of indigenous bauxite was used in the year 1948. 202,575 cwts. of wrought and unwrought aluminium valued at Rs. 2,71,65,643 were imported during 1948. The quantity of aluminium available for consumption was therefore 269,935 cwts. (67,360 plus 202,575). It may be observed that this import of aluminium in this country was due not to the actual deficiency of aluminium ore in this country but to the undeveloped condition of the aluminium industry. With the abundance of raw materials there are immense possibilities for this infant industry provided there is an adequate supply of cheap power. Apart from its limited use in the manufacture of aluminium, bauxite is required in small quantities in preparing alum, making high alumina cement, and for refining kerosene. At the present rate of its consumption in India, there is a surplus production of this mineral out of which some quantities are exported every year. The export of bauxite during 1948 amounted to 535 tons valued at Rs. 29,770.

Table 7.—*Quantity and value of Bauxite produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons	Rs.	Tons	Rs.
Bihar—				
Ranchi (Lohardaga) . .	5,878	47,024	5,226	41,808
Bombay—				
Belgaum	3,160	12,640	2,100	8,400
C. P. and Berar—				
Jubbulpore . . .	8,196	71,058	13,337	1,11,047
Madras—				
Salem	1,369	10,177	1,493	15,196
Vindhya Pradesh—				
Naged	1,303	17,594	..	..
Total .	19,906	1,58,493	22,156	1,76,451

TABLE 8.—*Quantity and value of Aluminium produced in India during the years 1947 and 1948.*

——	1947	1948
	Quantity in tons	Quantity in tons
Aluminium Produced	3,223	3,368
Alumina consumed in producing Aluminium	6,428	6,759
Alumina imported	3,487	1,993
Alumina produced from Bauxite	2,797	3,294
Bauxite used in producing Alumina	5,873	7,741

Bentonite

Bentonite is a certain variety of clay which consists mainly of a hydrated magnesium alumina silicate. It is used in foundry sands, in soap-making, in ceramics, for thickening mud in oil-well drilling, for filtering and decolourising oils, for roofing, etc. The U. S. A. is the largest producer of bentonite, which amounted to about 600,000 tons in 1946. In India, it is available mostly from Jodhpur and Kashmir in small quantities.

During the year 1948, the production of bentonite went down to 160 tons valued at Rs. 1,100 from 305 tons valued at Rs. 3,550 in 1947, there being no output of bentonite from Kashmir owing to disturbances. The shares of the producing areas are given below.

TABLE 9.—*Quantity and value of Bentonite produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons	Rs.	Tons	Rs.
Rajasthan—				
Jodhpur	200	400	120	600
Karauli	..	..	40	500
Kashmir	105	3,150	..	..
TOTAL	305	3,550	160	1,100

TABLE 10.—*Production of Building Materials and Road Metals in India during 1948.*

	Granite		Laterite		Lime		Limestone		Kankar	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.
Assam	28	375	9,368	60,090	195	7,974	58,052	3,23,006	..	..
Ajmer-Merwara	..	..	..	..	..	..	6,440	10,390	..	..
West Bengal	..	..	..	..	441	19,200	14,748	1,620	..	..
Bihar	..	..	..	..	..	..	889,121	44,31,971	..	..
Bombay	..	..	..	..	..	..	6,300	31,500	8,491	1,366
Bhopal	..	..	..	..	..	..	..	..	233	131
C. P. and Berar	..	..	..	..	2,380	37,789	(a)512,975	23,00,854	..	..
Delhi	..	..	..	..	..	..	..	..	..	..
East Punjab	..	..	..	..	..	..	..	..	16,760	9,645
Himachal Pradesh	..	..	..	..	..	..	..	..	..	..
Hyderabad	..	..	..	..	..	..	68,657	2,05,971	..	..
Madhya Bharat	..	..	..	..	..	..	105,947	2,05,262	..	..
Mysore	..	..	328	164	424	14,101	(b)5	50	505	604
Madras	108,741	3,49,145	122,924	1,45,787	9,904	7,69,350	676,798	16,59,228	..	..
Orissa	..	..	..	..	53,558	1,81,685	(c)772,529	29,21,626	..	..
Patiala and East Punjab States Union.	..	..	..	..	..	..	190,035	3,80,709	..	..
Rajasthan	..	..	..	..	..	..	320,904	7,95,099	29,195	6,76,915
Saurashtra	..	..	..	..	..	..	99,000	2,60,000	..	..
United Provinces	..	..	..	..	..	..	246,618	19,56,139	474,886	15,79,889
Vindhya Pradesh	..	..	..	..	..	..	89,369	5,45,397	..	..
TOTAL	108,769	3,49,520	132,620	2,06,041	66,902	10,30,049	4,057,498	1,60,28,822	530,070	22,68,550

(a) Includes 18,635 tons of Dolomite valued at Rs. 55,905.
(b) Dolomite.
(c) Includes 63,505 tons of Dolomite valued at Rs. 13.04,426.

TABLE 10.—*Production of Building Materials and Road Metals in India during 1948*—contd.

—	Marble		Sandstone		Slate.		Trap.		Miscellaneous Building materials and Road metals.		Total Value.
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	
	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Rs.
Assam	..	..	..	..	..	..	..	..	194,704	6,46,665	10,38,110
Ajmer-Merwara	500	3,000	..	..	..	.	..	..	17,480	79,440	92,830
West Bengal	..	..	..	..	..	..	..	..	10,880	38,823	59,643
Bihar	..	..	5,601	41,548	1,744	90,654	3,389	14,373	555,589	21,99,013	67,77,559
Bombay	..	..	..	..	..	..	..	..	465,880	10,20,093	10,52,959
Bhopal	..	..	..	..	..	..	..	..	11,628	69,414	69,545
C. P. and Berar	..	..	..	..	..	..	..	..	746,607	7,06,060	30,44,653
Delhi	..	..	..	..	..	..	..	..	..	..	..
East Punjab	..	..	..	..	8,635	3,48,050	..	..	24,827	51,349	4,09,044
Himachal Pradesh	..	..	..	..	1,000	30,000	..	..	..	..	30,000
Hyderabad	..	..	.	..	..	.	..	..	..	..	2,05,971
Madhya Bharat	..	..	6,618	2,000	793	65,464	..	..	..	..	2,72,726
Mysore	..	..	..	..	..	..	..	..	55,730	16,881	31,800
Madras	..	..	..	..	..	..	..	..	523,917	8,49,658	37,73,168
Orissa	..	..	..	..	.	..	..	..	21,601	1,63,652	32,66,963
Patiala and East Punjab States Union.	..	..	..	..	..	..	..	..	..	..	3,80,709
Rajasthan	12,780	3,73,078	387,379	27,51,097	123	6,585	..	..	338,519	5,42,254	51,44,973
Saurashtra	..	..	16,940	1,05,300	..	..	..	..	12,500	1,90,000	5,55,300
United Provinces	..	..	..	..	73	1,014	..	..	173,183	13,33,760	48,70,802
Vindhya Pradesh	..	..	..	..	..	..	..	..	346	5,668	5,51,065
TOTAL	13,280	3,76,073	416,538	28,99,945	12,368	5,41,717	3,380	14,373	3,153,291	79,12,730	3,16,27,820

Building Materials and Road Metal

The total estimated value of building materials and road metal produced in India during 1948 was Rs. 3,16,27,820 against Rs. 3,58,14,385 in 1947. In many returns, the quantities of building stones produced, were shown in cubic feet. These figures have been converted into tons on the basis of certain assumed relations between volume and weight. The resources of building materials in India are equal to those of any country and quite adequate for her own requirements, but they have not been utilized to the degree that the supply could easily provide for.

Limestone is the raw material from which lime and cement is derived and the fluxing agent in the smelting of iron ore. It is also used as building stone. In India deposits of limestone are widespread. Quarries have been opened up in every province except Bengal. With the growth of cement and steel industry in India, the production of limestone has been steadily increasing during the past few years. The production of limestone in 1948 was 4,057,498 tons including 82,145 tons of dolomite. The quantity of limestone and dolomite used as flux in the iron and steel industry during 1948 amounted to 767,048 tons, *vide* table 11.

TABLE 11.—*Flux (Limestone) used in the Iron and Steel Industry of India in 1948.*

	Tons
Tata Iron & Steel Co. Ltd.	
Indian Iron & Steel Co. Ltd.	207,790
Steel Corporation of Bengal Ltd.	24,030
Mysore Iron & Steel Works	38,844
Total	767,048

The raw materials that contribute to the production of cement consist mainly of gypsum, clay, and limestone—the most important of them all. Roughly 1·4 tons of limestone, besides gypsum and clay, go into the making of 1 ton of cement.

The total quantity of cement produced during the year 1948 was 1,563,659 tons. Therefore, the quantity of limestone used in the manufacture of the above quantity of cement, may be estimated at little more than 2 million tons (2,189,122 tons).

Calcite

There was a considerable fall in the production of calcite in India from 1,701 tons valued at Rs. 20,543 in 1947 to only 245 tons valued at Rs. 4,043 in 1948, there being no output from the district of Anantapur in Madras.

TABLE 12.—*Quantity and value of Calcite produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Madras—				
Anantapur	452	1,808	..	..
Rajasthan—				
Jaipur	1,249	18,735	222	3,330
Sirohi	..	..	23	713
TOTAL .	1,701	20,543	245	4,043

Chromite

Chromite is chiefly used for the preparation of the alloy ferro-chrome, the manufacture of chromium steels, for special furnace refractory materials and as a source for chromium salts such as bichromates, etc., and for the extraction of the metal for electroplating. The chromite ore as mined is graded according to chemical composition, *i.e.*, the percentage of chromic oxide which it contains. A minimum of 48 per cent. is generally required for metallurgical purposes, a lesser percentage is used for chemical and refractory purposes. For the manufacture of chromite refractory bricks the mineral is crushed to size and bonded with such material as magnesite or clay. The metal chromium is obtained in the form of an alloy, ferro-chrome, by smelting chromite an iron chromium oxide. The average annual world production during 1940-46 was a little over a million and a half metric tons.

Chromite is known to occur in Mysore, in the Singhbhum district of Bihar, in Keonjhar in Orissa, in Seraikela in Bihar, in the Salem and Kistna districts of Madras, in the Ratnagiri district of Bombay, and in Kashmir. According to available data India's known reserves are of the order of 200,000 tons of high grade ore containing 45 per cent. and above of Cr_2O_3, and the resources of lower grade ores are several times as much. Detailed prospecting is likely to prove these estimates to be conservative. Supplies of chromite are mainly obtained from Singhbhum, Keonjhar and Mysore. Mysore chrome ore usually has 40-48 per cent. Cr_2O_3 while that of Singhbhum varies from

41 to 48 per cent. There was a sharp decline in the production of chromite in India from 34,717 tons valued at Rs. 9,97,639 in 1947 to 22,555 tons valued at Rs. 7,05,963 in 1948, the mines in Keonjhar being responsible for this decline which is reported to have been due to lack of transport facilities, *viz.*, shortage of petrol and shortage of wagons as well as cancellation of certain leases for chromite in that area in 1947. The greater part of this output, *i.e.*, about 75 per cent. used to be exported abroad on the basis of Cr_2O_3 content varying from 41 per cent. to 50 per cent. In 1948, the quantity of chromite exported was however only 9,250 tons. This fall in the exports was also attributable to the difficulties of transport by rail throughout the year 1948. Consequently the larger proportion of chromite produced in this year was left over in stock and for consumption.

Hitherto the domestic consumption of the mineral lay chiefly in the manufacture of chrome bricks and refractories and to a smaller extent in the manufacture of chemicals for the tanning industry and also of steel. With the development of cheap power, there will undoubtedly be a greater scope for the manufacture of ferro-chrome, and chrome steels in India from high grade chrome ore which is adequate for her internal requirements for the present and near future.

TABLE 13.—*Quantity and value of Chromite produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Bihar—				
Singhbhum . . .	3,067	1,48,562	2,035	96,549
Madras—				
Kistna	153	6,380	1,727	1,03,640
Mysore—				
Hassan	9,869	3,34,897	9,336	3,53,130
Mysore	605	26,478	3,604	68,769
Orissa—				
Keonjhar	21,023	4,81,322	5,853	83,875
TOTAL .	34,717	9,97,639	22,555	7,05,963

Clays

Clays consist mainly of hydrous aluminium silicates, with variable impurities. The better quality white clay is known as china clay, and the variety suitable for producing firebricks is called fire clay. China clay invariably requires the removal of impurities by washing after excavation from the mine, while fire clay is sent in raw state to the firebrick factories where it is ground under rollers and screened to eliminate coarse particles.

As in most countries, India has ample resources of clay. There are workable deposits of china clay in almost every province. Those of fire clay and other clays are also widespread. There was a heavy fall in the production of china clay, from 66,561 tons valued at Rs. 14,62,994 in the year 1947 to 41,243 tons valued at Rs. 11,11,048 in 1948. This decline is particularly noticeable in Bihar, Madras, Mysore and Rajasthan, *vide* table 14. The output of fire clay however rose from 98,463 tons in 1947 to 121,718 tons in 1948. With regard to other clays, there was a slight fall in the production in 1948 as compared with 1947. Most of the Indian china clay is used in the textile and paper industries as fillers and in the pottery manufacture and the fire clay is used in the manufacture of firebricks. The other clays are used in the manufacture of building bricks, cement, soap and for colour washing. During the war years there was a steady rise in the production of china clay in India, particularly in Bihar, with a corresponding reduction in imports from 28,675 tons in 1940 to 315 tons in 1946. From the next year however, this process appears to have a tendency to reverse. 1,510 tons were imported in 1948 against 711 tons in 1947 and correspondingly there was about 40 per cent fall in the production in 1948.

Normally the present requirements of all the main users of china clay, with the exception of cotton mills, can be met from the Indian sources. The cotton mills import large quantities of china clay every year, because the Indian material is not pure enough to meet their requirements. The future development of the Kaolin industry in India therefore depends on whether the producers can improve the present methods of clay washing which at present are rather crude.

TABLE 14.—*Quantity and value of China clay produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Bihar	28,019	6,37,294	16,483	6,97,295
Bombay	993	50,870	784	77,105
C. P. and Berar . . .	629	4,279	1,328	10,452
Delhi	1,239	19,529	1,134	11,206
Hyderabad	1,877	46,925	2,439	31,113
Kashmir	760	450	..	..
Madras	6,022(*a*)	3,35,021	1,262	3,154
Madhya Bharat . . .	..	..	..	
Mysore	12,577	1,09,535	8,490	53,066
Orissa (*b*)	2,934	52,039	2,666	1,23,737
Rajasthan	4,494	58,599	480	12,725
Saurashtra	6,000	1,20,000	4,000	90,000
United Provinces . . .	271	3,700	177	1,195
Vindhya Pradesh . . .	746	18,753		..
TOTAL .	66,561	14,62,994	41,243	11,11,048

(*a*) Including 3,288 tons from Travancore.
(*b*) Including Mayurbhanj.

TABLE 15.—*Quantity and value of Fire-clay produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons	Rs	Tons	Rs.
Bengal	21,824	1,30,750	36,006	2,26,338
Bihar	23,385	1,59,488	30,092	2,03,452
C. P. and Berar . . .	24,381	1,40,913	28,666	2,08,402
Madhya Bharat . . .	170	9,000	..	..
Mysore	..	..	64	128
Orissa	17,804	50,396	18,624	70,957
Rajasthan	38	580	..	..
Saurashtra	10,000	2,00,000	7,500	1,50,000
Vindhya Pradesh . . .	861	4,305	766	6,128
TOTAL .	98,463	6,95 432	121,718	8,65,405

TABLE 16.—*Quantity and value of other Clays produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Assam	21,349	8,006	22,229	8,336
Bengal	6,685	10,830	6.425	10,494
Bombay	..	..	1,672	2,151
Central Provinces	108,381	3,69,826	234,893	4,76,654
Madras	106,700	1,08,798	1,880	1,565
P.E.P.S.U.	62,140	56,191	23,125	15,752
Saurashtra	4,000	1,00,000	1,000	20,000
United Provinces	246	548	23	12
Vindhya Pradesh	175	757	..	..
TOTAL	309,676	6,54,956	291,247	5,34,964

Coal

In addition to its direct use as fuel for power purposes a vast amount of coal is converted into coke for metallurgical and other purposes; some quantity of coal is also used for production of gas. The by-products from coal distillation provide the basis of several chemical industries. The average annual world production of coal during the years 1940-43 was of the order of 1,812 million metric tons.

The reserves of all workable coals in India down to 1,000 ft. depth have been calculated in 1932 in seams not less than 4 feet in thickness and containing not more than 25 per cent. ash, at 20,000 million tons and of good quality coals containing not more than 16 per cent. ash and in seams not less than 4 feet thick down to a depth of 2,000 feet, at 5,000 million tons. Reserves of coking coal for metallurgical use were then estimated to be of the order of 1,500 million tons. These figures were revised by the last Mining Committee of 1937 to 1,425 million tons, which on the assumption of 15 million tons of annual output and 50 per cent. extraction would be of the order of 1,065 million tons at the end of 1948. A recent Survey, however, has added to the above figures of reserves considerably.

The chief coalfields are in the Damodar valley in Bengal and Bihar; coalfields of varying size also occur in the Central

Provinces, Orissa and Hyderabad, as well as in Bikaner, Assam, Kashmir and Madras. The good quality coking coals are confined to the Jharia, Raniganj, Giridih and Bokaro coalfields in Bengal and Bihar.

During the year 1948, the total production of coal in India was 30,124,175 tons, 20,330 tons less than that in the previous year (1947) when the production rose to 30,144,505 tons, a record figure so far. The Bihar coalfields were mainly responsible for this slight decrease.

TABLE 17.—*Provincial production of Coal in India during the years 1947 and 1948 (in tons).*

——	1947	1948	Increase	Decrease
	Tons.	Tons.	Tons.	Tons.
Assam	355,001	358,050	3,049	..
Bengal (West) . . .	7,646,357	8,129,541	483,184	..
Bihar	17,318,165	16,345,249	..	972,916
Central Provinces (*a*) . .	2,590,411	3,005,132	414,721	..
Hyderabad	1,163,077	1,069,537	..	93,540
Kashmir	8,627	495	..	8,132
Orissa (*b*)	431,742	423,103	..	8,639
Rajasthan (Bikaner) . .	62,099	72,371	10,272	..
Vindhya Pradesh (Rewa) .	569,026	720,697	151,671	..
TOTAL .	30,144,505	30,124,175	1,062,897	1,083,227

(*a*) Including Korea. (*b*) Including Talcher.

This slight fall in the output was, however, accompanied by a little rise in the total value by about 3 per cent. The total value of coal produced in 1948 rose to Rs. 45,20,56,474, Rs. 43,77,20,245, being the total value of coal produced in the previous year. The average pit's mouth value per ton of coal in India in 1948 was Rs. 15 showing an increase of 7 annas over the average value in 1947, which was shared by all the provinces except Bihar.

Value of coal produced.

TABLE 18.—*Value of Coal produced in India during the years 1947 and 1948.*

—	1947		1948	
	Value	Value per ton.	Value	Value per ton
	Rs.	Rs. A. P.	Rs.	Rs. A. P.
Assam	73,54,580	20 11 0	78,74,544	21 15 0
Bengal	10,67,57,227	13 15 0	12,32,30,672	15 2 0
Bihar	25,71,71,727	14 13 0	23,65,38,292	14 8 0
Central Provinces (*a*) .	3,35,47,142	12 15 0	4,44,90,846	14 13 0
Hyderabad . . .	2,13,61,743	18 6 0	2,17,57,945	20 5 0
Kashmir . . .	72,090	8 6 0	4,950	10 0 0
Orissa (*b*) . . .	53,36,304	12 5 0	62,81,070	14 13 0
Rajasthan (Bikaner) .	5,93,252	9 9 0	7,56,672	10 7 0
Vindhya Pradesh . .	55,26,180	9 11 0	1,11,21,483	15 7 0
TOTAL .	43,77,20,245	.	45,20,56,474	..
Average value per ton .	..	14 9 0	..	15 0 0

(*a*) Including Korea. (*b*) Including Talcher.

Gondwana and tertiary coal measures.

The coal measures of India can be geologically classified as Gondwana and Tertiary. The difference in geological age between the two kinds of coal measures is naturally attended by differences in chemical composition—the Gondwana coals being largely bituminous, and the Tertiary largely lignitic. The Gondwana coalfields occur in Bengal, Bihar, Orissa, the C. P., Hyderabad and Vindhya Pradesh and the Tertiary fields in Assam, Rajasthan, Kashmir and Madras. As in previous years the output of Tertiary fields was but a trivial proportion of the whole, the proportion being 98·57 per cent. from Gondwana fields and 1·43 per cent. from the Tertiary fields in 1948.

TABLE 19.—*Origin of Indian Coal raised during the years 1947 and 1948 (in tons).*

—	1947		1948	
	Tons.	Per cent. of Indian total	Tons.	Per cent. of Indian total
Gondwana coalfields . .	29,718,778	98·61	29,693,259	98·57
Tertiary coalfields . .	425,727	1·39	430,916	1·43
TOTAL .	30,144,505	100·00	30,124,175	100·00

TABLE 20.—*Output of Gondwana coalfields during the years 1947 and 1948*

—	1947		1948	
	Tons.	Per cent. of Indian total	Tons.	Per cent. of Indian total
Bengal, Bihar and Orissa—				
Bokaro	2,602,998	8·63	1,970,897	6·55
Darjeeling. . . .	18,693	0·06	22,513	0·07
Giridih	501,735	1·67	464,803	1·54
Jainti	19,020	0·06	19,033	0·06
Jharia	11,788,631	39·11	11,494,339	38·16
Karanpura	978,695	3·25	840,398	2·79
Palamau (Daltanganj and Hutar).	32,197	0·11	35,130	0·12
Rajmahal Hills . . .	175	0·00	3,496	0·01
Ramgarh	57,127	0·19	69,726	0·23
Rampur (Hingir) . .	96,224	0·32	121,867	0·40
Raniganj	8,965,251	29·74	9,554,455	31·72
Talcher	335,518	1·11	301,236	0·99
Central Provinces—				
Ballarpur	224,414	0·75	270,279	0·90
Bilaspur	1,037	0·00	1,203	0·01
Korea	1,100,649	3·65	1,168,174	3·88
Pench Valley . . .	1,234,136	4·09	1,538,184	5·11
Raigarh	..	..	..	..
Yeotmal	30,175	0·10	27,292	0·09
Hyderabad—				
Kothagudam . . .	786,663	2·61	705,084	2·35
Sasti	62,094	0·21	53,482	0·18
Singarani	..	..	14,235	0·05
Tandur	314,320	1·05	296,736	0·98
Vindhya Pradesh—				
Johilla	176,871	0·59	248,668	0·82
Sohagpur	287,038	0·96	379,227	1·25
Umaria	105,117	0·35	92,802	0·3
TOTAL .	29,718,778	98·61	29,693,259	98·57

TABLE 21.—*Output of Tertiary coalfields during the years 1947 and 1948.*

—	1947		1948	
	Tons.	Per cent. of Indian total	Tons.	Per cent. of Indian total
Assam—				
Khasi and Jaintia Hills .	47,506	0·16	46,571	0·15
Lakhimpur . . .	271,939	0·90	274,757	0·91
Naga Hills . . .	19,848	0 06	21,162	0·07
Sibsagar	15,708	0·05	15,560	0·05
Kashmir	8,627	0·02	495	0·01
Rajasthan (Bikaner) . .	62,099	0·20	72,371	0·24
TOTAL .	425,727	1·39	430,916	1·43
Total of Gondwana coalfields .	29,718,778	98·61	29,693,259	98·57
Total of Tertiary coalfields .	425,727	1·39	430,916	1·43
GRAND TOTAL .	30,144,505	100·00	30,124,175	100·00

Hard Coke.

About two and a half million tons of coal are required annually for the manufacture of about 2 million tons of hard coke in India, more than 75 per cent. of which is used in the Iron and Steel industry. In the manufacture of hard coke, the coal is carbonised in the country 'beehive' and in the 'by-product' ovens and from the last named oven certain by-products, such as coal gas, tar, naphthalene, ammonia, benzol, etc., are recovered. Less than one million tons of soft coke are manufactured each year from inferior quality coals and used for domestic purposes. In the process of making soft coke no recovery of by-products is made.

TABLE 22.—*Quantity of Hard Coke produced in India during the years 1947 and 1948 (in tons).*

——	1947	1948
Coal used	2,629,319	2,378,817
Hard coke manufactured	1,843,194	1,643,960
Percentage of recovery	70·10	69·10
Source of coal used—		
Jharia fields	2,507,920	2,158,337
Giridih field	35,000	51,815
Raniganj field	68,128	148,853
Bokaro field	16,525	18,081
Lakhimpur (Namdang) field	1,746	1,731
TOTAL	2,629,319	2,378,817
Coal used for coking by—		
Two Iron and Steel Companies	2,315,285	2,024,018
Others	314,034	354,799

Soft Coke.

The quantities of Soft Coke despatched from West Bengal and Bihar coalfields since 1940 are given below:—

Years.	Tons.
1940	962,825
1941	957,553
1942	431,858
1943	354,835
1944	445,721
1945	547,292
1946	627,622
1947	225,130
1948	824,772

The production of coal tar in India came down to 65,078 tons in 1948 from 71,337 tons in 1947. The quantity of coal pitch produced by the Shalimar Tar Products (1935), Ltd., during 1948 was 2,263 tons against 3,750 tons in 1947.

TABLE 23.—*Production of Coal Tar in India during the years 1947 and 1948 (in tons).*

——	1947	1948
Bhowra Coke Company	1,322	1,342
State Railway Colliery, Giridih	844	1,370
Oriental Gas Company	3,194	2,991
Tata Iron and Steel Company	41,080	35,772
Indian Iron and Steel Company	19,045	17,339
Burrakur Coal Co , Ltd.	2,350	2,446
Bararee Coke Co , Ltd.	2,144	2,007
Lodna Colliery Co. (1920), Ltd.	1,348	1,811
TOTAL	71,337	65,078

Sulphate of Ammonia.

The details of the production of ammonium sulphate as by-product at the coking plants of iron and steel works and collieries in India are shown in table 24.

TABLE 24.—*Production of Sulphate of Ammonia in India during the years 1947 and 1948 (in tons).*

——	1947	1948
Tata Iron and Steel Co., Ltd.	12,452	11,116
Indian Iron & Steel Co , Ltd.	4,088	3,302
Burrakur Coal Co., Ltd.	894	917
Bararee Coke Co., Ltd.	964	877
State Railways Coal Dept., Giridih	(*a*)	(*a*)
TOTAL	18,398	16,212

(*a*) No operation of plant.

NOTE.—Besides the above, a quantity of 19,930 tons of sulphate of ammonia was produced by the Fertilizer Works in Travancore and Mysore during the year 1948 against 3,615 tons in 1947.

Exports and imports of coal.

The export of coal rose very high, about 2 million tons a year, during the first few years of World War II, but came down in the later years. Since 1946, it had been gradually rising again and amounted to 934,521 tons in the year 1948. India's export trade in coal is, however, not a vital factor to the industry. Her imports of coal have also been extremely small during recent years.

TABLE 25.—*Exports to foreign countries of Indian Coal and Coke during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Coal—				
To Aden and other Dependencies	..	..	1,180	2,48,880
„ Pakistan (Western)	..	..	372,646	77,28,472
„ Ceylon	137,648	28,80,548	249,346	1,05,76,899
„ Other countries	409,983	1,22,09,297	311,349	1,35,29,217
TOTAL	547,631	1,50,89,845	934,521	3,20,83,468
Coke	2,895	1,11,542	13,767	7,82,714
TOTAL of Coal and Coke	550,526	1,52,01,387	948,288	3,28,66,182

TABLE 26.—*Export of Coal under Grading Board Certificates during the years 1947 and 1948 (in tons).*

—	1947	1948
Selected grade	972,011	1,116,331
Grade I	460,317	569,112
Grade II	1,403	4,516
Grade III	3,572	69
Mixed Grade	3,028	19,373
Coal under reference	40,805	44,777
Ungraded	..	..
TOTAL	1,481,136	1,754,178

TABLE 27.—*Imports of Coal and Coke during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons	Rs.
Coal--				
From United Kingdom	200	10,000	15	5,222
„ Union of South Africa .	..	..	..	..
„ Other countries .	.	..	..	..
TOTAL .	200	10,000	15	5,222
Coke . . .	..	..	750	2,01,234
TOTAL of Coal and Coke .	200	10,000	765	2,06,456

TABLE 28.—*Excess of exports over imports of Coal (in tons).*

——	Exports	Imports	Excess of exports over imports
1947	547,631	200	547,431
1948	934,521	15	934,506

Consumption of coal.

By far the principal factor influencing the output of coal in India has been the development of her rail communications and demands of her industries. The greater part of India's output, *i.e.*, about 90 per cent. is used for steam raising and domestic purposes. The rest, *i.e.*, about 10 per cent. is consumed in the production of hard coke for metallurgical (principally iron and steel) industries of the country. Nearly 15 million tons of coking coal, forming about 50 per cent. of the total output of coal are consumed mostly for non-metallurgical operations. In view of India's very limited reserves of good quality coking coal, this state of affairs is serious. The main problems that face the coal industry at present are conservation and utilisation of good quality coking coals only for production of iron and steel and their possible use in other industries of the country, beneficiation of inferior coals by washing, recovery of by-products from coal distillation and utilization of the low grade coals for the manufacture of synthetic oil. The future of coal industry depends much on successful research on these lines.

The average number of persons employed daily in the coalfields during the year showed a slight decrease of about 4·2 per cent. The average rate of output per person increased from 82·82 in 1947 to 86·47 tons in 1948. The number of deaths by accidents rose from 287 in 1947 to 299 in 1948. During the year under review the number of deaths in the Raniganj fields of Bengal increased to 137 from 110 in 1947. The death rate was 0·86 per thousand employed in 1948 against 0·79 in 1947.

TABLE 29.—*Average number of persons employed daily in the Indian coalfields during the years 1947 and 1948. Also output per person, death rate, etc., for 1948.*

—	1947	1948	Output per person employed (in tons.)	Number of death by accident	Death rate per 000 persons employed
Assam	4,036	4,667	76·72	3	0·64
Bengal (West) . . .	89,024	88,012	91·75	137	1·55
Bihar . . .	208,114	192,899	84·73	100	0·52
Central Provinces* . .	29,020	30,205	99·49	14	0·46
Hyderabad . . .	18,221	16,303	65·60	37	2·23
Kashmir . . .	107	..	..	..	..
Orissa(*a*) . . .	5,896	6,445	65·65	1	0·15
Rajasthan (Bikaner) .	248	324	223·37	.	.
Vindhya Pradesh (Rewa) .	9,328	8,928	80·72	7	0·78
TOTAL . .	363,994	348,383	..	299	
Average for 1948 . .	..	..	86·47	..	0·86
Average for 1947 . .	..	..	82·82	..	0·79

*Including Korea.

(*a*) Including Talcher.

Copper-ore

In addition to its necessity in the electrical industry, the present-day uses of copper are manifold in engineering appliances either as copper or in brass, bronze and other alloys. As most sulphide copper ores contain under 4 per cent. copper, it is necessary to concentrate them, by eliminating much waste material before smelting. The crushed ore from the mine is ground to very fine size and treated in water with reagents. The mineral is then concentrated by the method of flotation. The average annual world production during 1940-46 was of the order of two and half million metric tons.

Occurrences of copper have been recorded in the Darjeeling district of Bengal, the Hazaribagh and Singhbhum districts of Bihar in the Balaghat, Jubbulpore and Saugor districts of the Central Provinces, Khetri in Jaipur, in Sikkim, in the Anantapur and Nellore districts in Madras and Chota Udepur in Bombay. The only deposits that are at present being worked, however, are those of Singhbhum and none of the other occurrences has yet been proved to be of economic importance. Two mining leases—one in the Balaghat district of Central Provinces and one in the Anantapur district of Madras are, however, reported to have been operating in the year 1948 and work has also been done in the Khetri deposit in recent years. The occurrences in the Singhbhum district are restricted to a copper bearing belt some 80 miles in length. In this belt, well defined lodes occur at the Rakha Mines, Mosaboni, Dhobani and Badia areas, the last three of which are held under concession by the Indian Copper Corporation Ltd. Throughout the year 1948, operations of the Corporation continued, although the labour position remained somewhat unsettled and coal was in short supply. The total tonnage of ore mined was 322,275 tons valued at Rs. 80,43,332 and was derived as follows:—

	Tons.
Mosaboni	209,800
Dhobani	23,279
Badia	89,196
TOTAL	322,275

The corresponding figure for the year 1947 was 323,033 tons valued at Rs. 60,34,318. The value of the ore increased although the quantity remained more or less the same. A total of 309,110 tons was treated in the mill at a valuation of Rs. 80,76,935. The Smelter produced 5,863 tons of refined copper valued at Rs. 1,700 per ton. A total of 6,479 tons of copper was issued to the rolling mills and 20 tons were sold as copper ingots. The rolling mill produced 9,527 tons of rolled brass, 26 tons of yellow metal circles and 10 tons of rolled copper.

The total ore reserves at the close of the year 1948 amounted to 2,461,091 short tons with an average assay value of 2·96 per cent. Cu. It is interesting to note that a small quantity of copper ore of about 6 tons was also obtained this year from Chota Udepur in Bombay. The same quantity was reported in the year 1946. It is understood that further investigation of this mineral was carried on in that area throughout 1948. As usual, the Rakha Mines in Singhbhum produced only 1 ton of copper-ore valued at Rs. 500. 40,195 tons of wrought and unwrought copper valued at Rs. 6,92,21,666 were imported into India during the year 1948 to meet the domestic demand. The quantity of copper available for consumption in this year was, therefore, 46,058 tons (5,863+40,195). India's deficiency in this metal calls for intensive prospecting operations of the promising areas.

Corundum

Corundum powder is used as an abrasive either in the loose form or bonded into grinding wheels. In India corundum deposits are known in Khasi hills in Assam, Rewa, the South Kanara and Salem districts of Madras, Mysore and Kashmir. Supplies are obtained chiefly from the Salem district of Madras, Rewa and Mysore. An output of 280 tons valued at Rs. 31,090 was reported in 1948 against 179 tons valued at Rs. 48,760 in 1947. The shares of the producing areas are given in table 30. The production is now largely exported abroad. Corundum is a natural abrasive, but in recent years the artificial products are considerably replacing the natural abrasives. However, the raw materials being readily available, there are possibilities of developing this industry, should cheap electrical power be obtained in the near future.

TABLE 30.—*Quantity and value of Corrundum produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Assam (Khasi State) . .	..	..	17	(a)340
Mysore (Hassan Dist.) . .	83	16,600	237	23,750
Vindhya Pradesh (Rewa) .	96	32,160	26	7,000
TOTAL .	179	48,760	280	31,090

(a) Estimated.

Diamond

Diamonds are known to occur in Cuddapah, Anantapur, Bellary, Kurnool districts of Madras and in the Panna, Charkhari, Bijawar, Ajaigarh States of the Vindhya Pradesh. Production has generally been reported from the latter area, and about 95 per cent. of the recorded production comes from the Panna State. The output of diamond in Vindhya Pradesh increased considerably from 1,284 carats valued at Rs. 1,72,652 in 1947 to 2,426 carats valued at Rs. 4,17,373 in 1948. The whole of the output came from Panna and Charkhari States their respective shares being 1,214 and 1,212 carats. A quantity of 37,376 tolas of emerald valued at Rs. 2,51,834 was reported from Mewar after several years. This increase in the production of precious stones can be attributed to the restrictions on the importation of precious stones into India from the year 1947.

Feldspar is generally used in ceramic and glass industries. Before mixing with the ceramic or glass batch, it is carefully cobbed and hand picked to remove foreign minerals and finely ground. Deposits of feldspar occur in Ajmer-Merwara, Alwar, Sirohi, the Burdwan district in Bengal, the Chhindwara and Jubbulpore districts in the Central Provinces, the Trichinopolly district in Madras, Mysore, Rewa, etc. Production has been reported from all these areas in recent years. The output of feldspar in India fell from 1,722 tons valued at Rs. 16,874 in 1947 to 987 tons valued at Rs. 10,466 during the year 1948. This was due to the absence of production mainly from Trichinopoly, Mysore and Rewa. The output is at present mainly consumed in the ceramic industry in India. India has large resources of this mineral which can be developed to meet her domestic requirements. A great deal of feldspar can also be obtained from the dumps of mica mines as a by-product.

Table 31.—*Quantity and value of Feldspar produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Ajmer-Merwara . . .	178	1,681	393	3,743
Central Provinces—				
Chhindwara . . .	788	7,176	440	4,850
Jubbulpore . . .	19	239	..	..
Madras—				
Trichinopoly . . .	228	2,391	..	..
Rajasthan—				
Alwar . . .	5	215	5	180
Sirohi	30	236	140	1,693
Mysore—				
Hassan	294	4,696	..	.
Vindhya Pradesh—				
Rewa . . .	180	240	..	..
Total .	1,722	16,874	987	10,466

Fuller's Earth

The term "Fuller's Earth" is applied to non-plastic clays which has the power to absorb oil and grease. It is used in preparing medicinal tabloids. It is also used in India as detergent agent for washing clothes. India's supply of this material is mainly obtained from Bikaner, Jaipur, Jodhpur, Jaisalmer, Jubbulpore and Mysore. There was a very large increase in the production of fuller's earth from 2,831 tons valued at Rs. 29,104 in 1947 to 6,011 tons valued at Rs. 1,72,776 during the year 1948. Since it is not exported out of India, this sudden rise in its production can be ascribed to its increased domestic demand.

TABLE 32.—*Quantity and value of Fuller's Earth produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Central Provinces—				
Jubbulpore . . .	22	299	87	1,186
Rajasthan—				
Bikaner	..		2,743	1,18,000
Jaisalmer . . .	109	1,805	175	5,290
Jodhpur	2,700	27,000	3,006	48,300
TOTAL .	2,831	29,104	6,011	1,72,776

Garnet sand

The material makes a very satisfactory abrasive for some classes of work where carborandum or emery is too hard. In India, garnet sand is available from Madras, Mysore and Rajasthan, which can be crushed and sieved to various degrees of fineness and coarseness for use as abrasive powder. In the year 1947, an output of 8 tons of garnet valued at Rs. 800 was reported from Kolar in Mysore. No production was reported in the year 1948.

Gold

Most of the gold produced in the world is used either for currency and exchange purposes or for the manufacture of ornaments. A little is used in the manufacture of industrial and scientific appliances, and a very small amount finds its way into chemicals. The average annual world production of gold during the years 1940-46 was about thirty million fine ozs.

India's supply of this mineral is obtained almost entirely from Kolar goldfields. Very small amounts are also recovered from alluvium or gravel in U. P., Bihar, Orissa and Madras. It also occurs in Hutti in Hyderabad where three mines were worked till 1921, and it is encouraging to note that these mines were reopened during the year under review, and went into production, yielding 384·19 ozs. of gold valued at Rs. 1,36,327. There was some increase in the production of gold in the Kolar goldfields from 171,695·6 ozs. valued at Rs. 4,89,52,339 in 1947 to 180,039·8 ozs. valued at Rs. 5,41,82,355 during the year 1948. This increase has been maintained steadily from 1946 when the production of gold went down to 131,718 ozs. from 314,501 ozs. in 1939.

The mines in Kolar gold fields are very efficiently managed. All the latest methods of mining are adopted there for successful extraction of the gold quartz at increasing depths and under increasingly difficult conditions. Of the four mines, Mysore, Nundydroog, Ooregaum and Champion Reef—that are producing gold, the last two are the deepest and reached during the year vertical depths of 9,376 ft. and 8,936 ft. respectively below field datum or 6,408 ft. and 5,968 ft. below mean sea level. The dip of the reef at these depths is almost vertical. The ore is free milling and yields its gold to blanket concentration and cyaniding, all sliming practice being now general.

The rock temperature recorded at the 97th level in Ooregaum mine, 9,128 ft. below field datum, was 143° F., the geothermic gradient at this depth showing a rise of 1° F in 107·5 ft. Owing to great depths of these mines and consequent high temperature, the maintenance of adequate ventilation at the working faces is extremely difficult and it has been solved to a great extent by providing smooth-lined vertical shafts, elliptical or circular, to serve as main airways and by an extensive use of electrically driven fans erected at suitable places to ensure the supply of the requisite quantity of air. In addition, the Ooregaum, Champion and Nundydroog Mines have installed, at the top of their main down-cast shafts, air-conditioning plants of the Ammonia Compressor Type using brine in coil type coolers. The erection of a similar plant in the Mysore Mine, which had been in progress for some time, was completed and the plant was put into commission in June, 1948. All the four air-conditioning plants delivered during the year 120,000-155,000 cu. ft. of air per minute at a mean wet bulb temperature ranging from 36·7° F. to 40·5° F. against a mean atmospheric wet bulb temperature of

67·4° F. The year was marked by a number of strikes although these were of short duration. They were, however, not serious enough to cause an appreciable reduction in output and development footage. The average number of persons at work in the Kolar gold field during 1948 was 23,889 of whom 14,996 were employed below ground and 8,893 on surface.

In regard to gold, India is just self-sufficient for her own requirements which are mostly for ornaments. Before the war, gold was exported in large quantities, so much so that Government was forced to take control measures to check the flow, with the result that the exports rapidly declined towards the close of the war. In the year 1948, there was no export of gold.

India is normally an importer of some gold in the form of bullion and coins. In 1948, this import sharply declined to 4,330 ozs. valued at Rs. 12,11,040 from 644,889 ozs. valued at Rs. 16,51,56,819 during the year 1947.

TABLE 33.—*Quantity and value of Gold produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Ozs.	Rs.	Ozs.	Rs.
Madras	7·0	1,700	..	..
Mysore	171,695·6	4,89,52,339	180,039·8	5,41,82,355
East Punjab	..	..	5·4	1,375
United Provinces	2·4	600	·4	100
Hyderabad	..	..	384·19	1,36,327
TOTAL	171.705·0	4,89,54,039	180,429·79	5,43,20,157

Graphite

Graphite is used mainly for the manufacture of crucibles for furnace operations, as a facing to foundry moulds, in paints, in pencils and in lubricants. Concentration of graphite may be effected by washing the ground mine product and separating the accompanying grit. Graphite occurs in small quantities in various parts of India—in Orissa, Hyderabad, the Central Provinces, Travancore, Ajmer-Merwara, Mewar, Madras and Mysore. With the exception of Hyderabad, production was reported from all these areas during the last decade. It rose considerably during the war years owing to the paucity of supply from abroad. This rise was maintained in the post-war years, and reached the peak of 1,649 tons valued at Rs. 2,64,349 during the year 1948. The number of leases for this mineral reported to have been existing in India during 1948 was 15 of which 13 were held in the C. P. and Orissa. The increase in production was however accompanied by imports of graphite in considerable quantities. This indicates that India's requirements of graphite—which are mostly for foundry purposes and pencil manufacture exceed her existing supplies. 21,997 cwts. (1,100 tons) of graphite and graphite crucibles valued at Rs. 12,65,334 were imported in 1948. The quantity of this mineral available for consumption during this year was therefore 2,749 tons (1,649+1,100). India's deficiency in this mineral demands intensive development of her known resources.

TABLE 34.—*Quantity and value of Graphite produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Central Provinces—				
Betul	159	5,760	578	1,68,727
Hyderabad	35	6,125	..	..
Mysore—				
Kolar	..	..	218	11,990
Orissa—				
Athmallik	215	27,305	310	31,310
Koraput	143	51,300	62	20,686
Patna	633	55,704	296	4,405
Sambálpur	50	9,123	185	27,231
TOTAL	1,235	1,55,317	1,649	2,64,349

Gypsum

Gypsum is used for the manufacture of ammonium sulphate and sulphuric acid. It is also used in the manufacture of cements, paints and paper. On calcining it is converted to plaster of Paris. Gypsum occurs both in massive form and as clear selenite crystals, and when raised from the mine is more or less free from other impurities. The average annual world production during the years 1940-46 was little over eight million metric tons.

The supplies of gypsum in India are obtained chiefly from the States of Bikaner, Jodhpur, Jaisalmer, Madras and Kathiawar (now called Saurashtra). Deposits are also known to occur in the United Provinces, Sirmur in Himachal Pradesh, Rewa in Vindhya Pradesh, Cutch and Bhutan. But some of these are either not fully explored or they lie at too great a distance from the existing lines of communication to be of commercial utility. The total reserves, so far estimated are roughly of the order of 55 million tons, the share of Trichinopoly in Madras being about 15 4 million tons, that of Bikaner, Jaisalmer and Jodhpur being about 28 million tons, and that of Saurashtra, Cutch and Himachal Pradesh about 11 5 million tons.

During the year 1948 the reported output of gypsum amounted to 78,948 tons valued at Rs. 7,98,261 against 50,569 tons valued at Rs. 4,66,283 in 1947. This large increase in production, for which the mines in Bikaner and Trichinopoly were responsible (*vide* table 35) was no doubt due to the growing demand of this material in India, as no gypsum is reported to be exported abroad. A small quantity of gypsum is known to be imported in the form of plaster of Paris. Roughly the quantity produced in India may therefore be reckoned to represent India's consumption at present. So far, the cement industry has been the main consumer of gypsum in India. It is also used in the manufacture of ammonium sulphate in Travancore and Mysore as well as in making plaster of Paris for various purposes. The consumption of gypsum will increase enormously when the proposed fertiliser plant at Sindri is put into commission in the near future. It is estimated that this factory will require 2,000 tons of gypsum per day. In the circumstances, the deposits of gypsum will have to be fully explored to balance the increased consumption in the years to come unless the deficit is made up by imports.

Table 35.—*Quantity and value of Gypsum produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Madras—				
Trichinopoly . . .	16,380	2,01,059	26,936	4,07,938
Rajasthan—				
Bikaner	2,874	20,118	26,330	2,55,087
Jaisalmer	315	3,106	402	5,166
Jodhpur	21,000	(a)42,000	20,000	30,000
Saurashtra . . .	10,000	2,00,000	5,000	1,00,000
United Provinces—				
Garhwal Dist. . .	..	..	280	70
Total .	50,569	4,66,283	78,948	7,98,261

(a) Value estimated.

Ilmenite

This is a titanium-bearing iron-ore which may have up to 32 per cent. titanium. It is used for the extraction of titanium dioxide which is a valuable pigment. Titanium metal is an important alloying element in high speed steel. India is the largest producer of ilmenite in the world. About 75 per cent. of the average annual production of the world comes from India. The material is obtained from the beach sands of Travancore and along the east coast of India. The reserves of ilmenite are roughly estimated to be of the order of 200 million tons. The ilmenite bearing beach sands of Travancore are concentrated on wet tables to remove quartz sand, and then after drying, the ilmenite is removed by magnetic separators, leaving monazite, zircon, sillimanite, etc., 229,416 tons of ilmenite valued at Rs. 31,36,697 are reported to have been produced in Travancore during the year 1948 against 260,955 tons valued at Rs. 31,59,271 in the year 1947. The quantity produced is entirely exported out of India. The exports of ilmenite during 1948 amounted to

247,221 tons of which 206,249 tons were shipped to U. S. A. and 37,446 tons to the U. K.

So far there has been no consumption of ilmenite in India. Plans are, however, known to be under way for the construction of a factory for the manufacture of titanium dioxide in Travancore. India enjoys an exportable surplus of this mineral and can continue to do so for several years to come after meeting the requirements of her domestic market.

Iron-ore, Pig Iron and Steel

There are many types of iron ore, hematite, magnetite, siderite, laterite, etc., but the first occurs in rich deposits and is more commonly used. The iron-ore reserves of the world are incalculable, the largest deposits occurring in countries where the production is yet small as in India and Brazil. India has iron-ore reserves of hematite which are second to none either in quantity or quality.

Extensive deposits of iron-ore occur in several parts of India, *viz.*, Bihar, Orissa, the Central Provinces, Madras and Mysore. Of these the deposits in the Singhbhum district of Bihar, and in the adjacent areas of Bonai, Keonjhar and Mayurbhanj which have now merged with Orissa are the most important being the largest in extent as well as richest in iron content.

The estimated reserves of the major deposits of India are as follows:—

—	Million tons.	Iron content per cent.
Singhbhum and Orissa	8,000	60—68
Drug District, C. P.	175	60—68
Bastar State, C. P.	14,10	60—68
Chanda District, C. P.	30	60—68
Mysore	150	55—65
Madras (Salem Dist.)	505	35—40
Sandur, Madras	130	
TOTAL . .	10,200	

The average annual world production of iron-ore during the years 1940-46 is of the order of 200 million metric tons of which the share of India is very small. Yet India is the largest producer of iron-ore in the Commonwealth of Nations outside the U. K. During the years 1939-43 the production of iron-ore rose above 3 million tons a year, but gradually came down to 2,264,184 tons in the year 1945. It rose slightly to 2,498,459 tons in the year 1947, but has again dropped to 2,284,587 tons in the year 1948, the mines in Mayurbhanj being responsible for this fall. The reasons for this fall in output from this area are reported to be less demand of iron-ore in Tata's Works and dearth of labour. The value of iron-ore however rose appreciably in comparison with that in the previous year. Details of production and value are given in the following table.

TABLE 36.—*Quantity and value of Iron-ore produced in India during the years 1947 and 1948.*

	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs
Bihar—				
Singhbhum . . .	1,105,767	43,32,231	1,145,034	56,27,870
Central Provinces .	637	19,162	224	14,340
Mysore	50,150	(*a*)1,50,450	53,050	7,40,200
Orissa—				
Keonjhar	403,980	6,53,537	432,194	11,85,936
Mayurbhanj . . .	937,925	29,12,425	654,085	27,31,111
TOTAL .	2,498,459	80,67,805	2,284,587	1,02,99,463

(*a*) Value estimated.

Of the total of 1,145,034 tons produced in Singhbhum, 781,797 tons were produced by the Tata Iron and Steel Co., Ltd., and 362,994 tons by the Indian Iron and Steel Co., and 243 tons by a small firm. The figures shown against Keonjhar represent mainly the production of Messrs. Bird and Co. The whole of the production reported from Mayurbhanj was obtained by the Tata Iron and Steel Co., Ltd.

Pig Iron.

The Indian Iron and Steel Industry is well established. Since 1941, when the exports of iron-ore from India ceased, all the iron-ore produced is being smelted in the country for reduction to pig iron and the rolling of steel. The amount of iron-ore consumed in the making of 1,455,093 tons of pig-iron during 1948 was 2,348,040 tons, *i.e.*, 63,453 tons more than what was mined during the same year. It is however important to note in this connection that a small quantity of iron-ore of Goan origin weighing 8,323 tons was shipped to Japan from the port of Mormugao during the year under review. The total annual capacity of the blast furnaces of the three pig iron producing concerns in India is little over 2 million tons, details of which are given below:—

	Ton
Tata Iron & Steel Co., Ltd.	1,250,000
Indian Iron and Steel Co., Ltd.	734,000
Mysore Iron and Steel Works	26,000
	2,010,000

As stated before the total quantity of pig iron produced in India during 1948 was 1,455,093 tons as against 1,526,847 tons in 1947, Indian Iron & Steel Co., Ltd. being responsible for this fall in production. Details of the output are given in tables 37, 38, 39. Considerable quantities of pig iron, more than half a million tons (about ⅓ of the production) used to be exported before 1941 since when the exports generally dwindled and come down to 1,730 tons in 1947. In the year 1948 however the exports increased to 39,751 tons.

TABLE 37.—*Pig Iron produced by the Tata Iron and Steel Co., Ltd., in 1947 and 1948 (in tons).*

—	1947	1948
Bessemer Pig	719,473	738,200
Basic Open Hearth	139,497	141,704
Pig casting Machine	72,864	31,982
Foundry Grade	34,533	37,955
TOTAL	966,367	949,841

TABLE 38.—*Pig Iron produced by the Indian Iron and Steel Co., Ltd., during 1947 and 1948 (in tons).*

—	1947	1948
Foundry	404,243	323,306
Basic quality	132,691	159,881
TOTAL	536,934	483,187

TABLE 39.—*Production of Pig Iron in India during the years 1947 and 1948 (in tons).*

—	1947	1948
Tata Iron & Steel Co., Ltd.	966,367	949,841
Indian Iron and Steel Co., Ltd.	536,934	483,187
Mysore Iron and Steel Works	23,546	22,065
TOTAL	1,526,847	1,455,093

Steel.

About 75 per cent. of the pig iron smelted in India is now absorbed in the manufacture of steel, and the rest in other kinds of iron products, these being very little left over for export. The amount of pig iron used in the manufacture of 942,038 tons of steel during 1948 was 1,089,575 tons. The total annual ingot capacity of the steel furnaces of the three steel producing concerns in India is of the order of 1 4 million tons details of which are shown below:—

	Tons.
Tata Iron and Steel Co., Ltd.,	1,050,000
Steel Corporation of Bengal, Ltd.	350,000
Mysore Steel Works	30,000
TOTAL	1.430,000

But since 1946 the production of steel remained between 9 and 10 lakh tons. In 1948 it was a little less than that of the previous year—*vide* table . The fall in the production of pig iron and steel may be ascribed to the obvious causes which have generally affected the Indian industries after the war, *i.e.*, labour troubles and transport difficulties, shortage of machinery and equipment. In this connection, it is interesting to note that the average annual world production of steel also came down from 153 million tons during the years 1940-44 to 117 million tons during the years 1945-47.

TABLE 40.—*Steel produced in India during 1947 and 1948 (in tons).*

—	1947	1948
Tata Iron and Steel Co., Ltd.	674,737	663,182
Steel Corporation of Bengal, Ltd.	248,999	223,738
Mysore Iron & Steel Works	22,146	55,118
TOTAL	945,882	942,038

Value of Pig Iron & Steel.

Out of the total production of 1,455,093 tons of pig iron in India in 1948, the steel industry absorbed 1,089,575 tons leaving a balance of 365,518 tons. The value of this balance of pig iron at the rate of Rs. 85 per ton is Rs. 3,10,69,030. The value of the total quantity of 942,038 tons of steel produced at an average rate of Rs. 312-8-0 per ton is Rs. 29,43,86,875. In addition, the output of 9,140 tons of ferro-manganese produced in 1948 estimated at an average price of Rs. 450 per ton has a value of Rs. 41,13,000. Thus the total value of the metallic products obtained from iron-ore is Rs. 32,95,68,905 which is more than 32 times the original value of the iron-ore.

Consumption of Iron & Steel materials.

Excepting machinery, cutlery and hardware, about 141 thousand tons of iron and steel fabricated materials were imported into India during the year 1948. The quantity of iron and steel materials (finished steel and iron castings) manufactured in India during the same year was nearly one million tons. Therefore, the above imports constituted about 13 per cent. of the total quantity (production plus import minus export) available for consumption which amounted to little over one million tons. The requirements of the country are on the increase owing to growing demands from the Government for several projects of post war development as well as from the public for various construction works. These additional demands will have to be met by imports from abroad unless production of iron and steel materials in the country increases correspondingly.

India has the potentialities of a very large producer of iron and steel because of her enormous resources of high grade iron ores and certain related minerals like manganese ore, chromite, titanium, vanadium ores. With a steady programme of expansion of the iron and steel industry, *i.e.*, development of the existing iron and steel works and erection of new plants at suitable places—it should be possible not only to meet the internal demands but also to export these materials abroad in large quantities in no distant future.

Kyanite and Sillimanite

Kyanite and sillimanite are aluminium silicates having the same chemical composition. These minerals are used in the manufacture of high quality refractory bricks especially for furnaces required for glass melting. They are also made into high quality and electrical porcelains, such as are used in spark plugs. As mined in India kyanite is practically pure and needs merely to be hand sorted to reject material high in silica and iron.

The workable deposits of kyanite occur in Seraikela and Kharsawan in the Singhbhum district, Bihar. Small deposits are also known to occur in the Manbhum district in Bihar and in Mayurbhanj, in the Nellore district in Madras, in Mysore and in Ajmer-Merwara. The great Lapsa Buru deposit in Kharsawan is the largest of its kind in the world. The reserves are estimated to be 214,000 tons within a depth of only 3 ft. Ten times as much would be available if the whole material and debris in depth are taken into account. Practically the whole of the output of kyanite used to be exported prior to 1938 since when a certain quantity about 1,200 tons a year, has been utilized in India in the manufacture of glass plant refractories known as " sillimanite blocks ". With the expansion of glass and ceramic industries, domestic market for kyanite will increase as a matter of course. Meanwhile India can afford to export this mineral for some years to come without detriment to the development of home industries.

Deposits of sillimanite are known to occur in Assam, Rewa, the Central Provinces and Bastar, of which those in the Khasi Hills in Assam are workable though difficult of access. They are associated with a little corundum and are believed to contain 251,000 tons of sillimanite at a conservative estimate. After a lapse of 27 years work has been resumed in this deposit since 1948 and it has yielded 190 tons. Supplies of sillimanite sands are obtained from the sea beaches of Travancore. It is recovered as a by-product in the process of magnetic separation of ilmenite from monazite. The quantity of sillimanite produced in India either in the form of sand or rock is wholly exported. The output of kyanite, of quartzite, and similar rocks is shown in tables given below.

Table 41.—*Quantity and value of Kyanite, Quartzite, Sillimanite and Quartz-mica-schist produced in India during 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Kayanite	14,351	5,99,282	12,605	5,68,182
Quartz-mica-schist	80	1,860	..	..
Quartzite	284	6,603	48	480
Sillimanite	236	20,299	(a)213	16,007
Total	14,951	6,28,044	12,866	5,84,669

(a) Including 23 tons of sillimanite sand from Travancore.

TABLE 42.—*Kyanite produced in India during the years 1947, 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Bihar—				
Singhbhum district—				
Kharsawan . . .	12,173	5,47,793	11,617	5,23,765
Seraikela . .	1,317	43,461	575	25,875
Madras—				
Nellore	..	..	84	3,360
Mysore—				
Hassan	..	..	192	11,490
Orissa—				
Mayurbhanj . . .	861	8,028	137	3,692
TOTAL	14,351	5,99,282	12,605	5,68,182

The production of kyanite fell from 14,351 tons valued at Rs. 5,99,282 in the year 1947 to 12,605 tons valued at Rs. 5,68,182 in the year 1948. This fall in production which was mainly from the Mines in Kharsawan, Seraikela and Mayurbhanj is stated to have been generally due to transport difficulties. Some production of kyanite was however reported for the first time from Madras since 1940 and from Mysore since 1934. An output of 23 tons of sillimanite sand was obtained from Travancore. As already mentioned above, 190 tons of sillimanite were won from Khasi Hills in Assam. There was no production of quartz-mica-schist from Singhbhum. Mysore produced 48 tons of quartzite.

Lead ore

Lead ore is primarily used for the extraction of metallic lead, by smelting in a blast furnace. The lead besides being used for various purposes as a metal is also used in the preparation of pigments known as white lead, red lead. Before smelting lead ore has to be crushed, ground and concentrated by the flotation method. The average annual world production of lead during the years 1940-46 was about 1 million and a half metric tons.

Small deposits of lead ore have been recorded in various places in India, the most important being those of Zawar in Mewar. These deposits have been held under mining lease by the Metal Corporation of India, Ltd., since 1945 and are being successfully worked by them. Two other mining leases, one in Orissa, and another in Chota Udepur in Bombay are reported to have been existing in India in 1948. The lead zinc mines at Zawar were opened by the Geological Survey of India during the war period. Towards the end of war, Government came to the conclusion that no lead ore or zinc from Zawar could be made available in time to be of any value for war purposes, and the property was therefore handed back to Mewar State and a fresh lease was granted by the State to the Metal Corporation of India, Ltd., in 1945. From the beginning of the operation up to the end of March, 1949, the Corporation raised about 18,755 tons of ore. Pending installation of an ore-dressing plant which the Corporation had arranged to set up at the mines area, the ores continued to be hand-dressed and despatched to their factory at Katrasgarh for smelting since 1945. During the year 1948-49, a quantity of 1,325 tons of lead concentrates was obtained by hand dressing and about 542 tons of lead metal valued at Rs. 7,04,600 were recovered by smelting about 1,600 tons of concentrates, of which 68 tons were obtained from the Banjari Mines in Jaipur. These handpicked ores have generally about 50 per cent. metal content.

The ore containing a good proportion of zinc were left at the mine site to be concentrated in the ore-dressing plant when erected. The Corporation also held a mining concession over the lead mines of Banjari in Jaipur till May 1948 when it was cancelled by them as it did not prove to be of economic importance.

1,72,644 cwts. of lead metal valued at Rs. 1,16,63,495 and 689,311 cwts. of zinc valued at Rs. 3,49,63,593 were imported into India during 1948 to meet the requirements of the country which is almost entirely dependent on foreign supply of these metals. In these circumstances, every encouragement and help is due from the Government and industrialists to the present lead-zinc industry in Zawar.

Magnesite

The principal uses of magnesite are for making refractory bricks for metallurgical furnaces, oxychloride or sorel cement. and for the extraction of the metal magnesium. When used for the manufacture of refractory bricks, crude magnesite is dead burnt in kilns at about 1,600c and then ground to a fine powder to be moulded into bricks. Magnesium metal can be extracted from calcined magnesite by direct heat treatment or by electrolytic process. The average annual world production of magnesite during the years 1940-45 was a little over one and a half million metric tons.

The chief producing centres of magnesite in India are the Salem district in Madras, the Hassan and Mysore districts of Mysore; but deposits of this mineral occur at a number of other places in India such as Coorg, the Kurnool and Trichinopolly districts of Madras, Singhbhum in Bihar, Idar and Dongarpur in Rajasthan, and Kumaun Division in the U. P. The deposits in the U. P. have been discovered recently and found to be of large extent. The mineral is won in India by open quarrying and contains about 46 per cent. magnesia. During the year 1948 a total output of 48,327 tons valued at Rs. 6,61,015 was reported against 51,536 tons valued at Rs. 6,86,956 in the year 1947, which were obtained solely from the Salem district. The output of 48,327 tons was shared between Salem and Mysore the former producing 47,245 tons and the latter 1,082 tons. The working of the magnesite mines in Mysore was resumed in 1948.

India has large and rich deposits of magnesite enough for her domestic requirements as well as for export. 283,426 cwts. of (14,171 tons) magnesite were exported in the year 1948. About 25 per cent. of the annual production was found to have been exported during several years past, and the rest, *i.e.*, about 75 per cent. was consumed mostly in the manufacture of refractory bricks for the iron and steel works in India. Caustic magnesia for oxychloride cement is little used in India, although it is possible to develop an Indian market of this valuable product by demonstrations of its utility. The occurrence of large quantity of good quality magnesite with the supply of cheap electricity both in the Salem and Mysore districts may be favourable to the economic production of magnesium metal.

Manganese-ore

Manganese-ore is mostly used for metallurgical purposes, *i.e.*, for the manufacture of pig iron, steel and ferro-manganese. High grade ore is used in the chemical, ceramic and glass industries and in dry batteries. In the manufacture of pig-iron or steel, the ore is required to be crushed before it is added direct to the blast or steel furnace. In making ferro-manganese, the ore is reduced in a blast furnace in the same manner as for the production of pig iron. For use in the dry batteries, or in the glass, ceramic and chemical industries the ore must be finely ground. The average annual world production of manganese during the years 1940-45 was of the order of four and a half million metric tons.

India has extensive workable deposits of manganese-ore distributed in several parts of Chotanagpur in Bihar, in Orissa, the Central Provinces, Madras, Mysore and Bombay and Madhya Bharat and Rajasthan. The most important of these deposits in quality and quantity are those of the Central Provinces. In the absence of data derived from drilling it is not possible to estimate the reserves of this mineral. They are undoubtedly considerable, the greater part of the reserves being of the first grade (48 per cent. and over). In India most of the manganese-ore is mined by opencut methods and graded according to its manganese content. The first grade ore contains over 48 per cent. Mn, the second grade ore between 45 and 48 per cent. Mn, and the third grade below 45 per cent. Mn. Generally speaking manganese ores from the C. P., Bombay, and Bihar are of the first grade, those from Orissa and Madhya Bharat (Jhabua) of the second grade and those from Madras, Mysore and Rajasthan of the third grade.

The production of manganese ore rose over 1 million tons in 1937, but thereafter gradually declined during the war years to only 210,583 tons in 1945. Since then it has been on the increase. The output of manganese ore in India during the years 1947 and 1948 is shown in table 43. It increased from 451,034 tons valued at Rs. 96,40,563 to 525,876 tons valued at Rs. 1,78,49,256. The mines in the C. P. and Sandur contributed to this 16 per cent. increase which may be attributed to its greater demand in the foreign market, particularly in the U.S.A. The total value of manganese-ore also rose during this year owing to the appreciation of the average price per unit of manganese.

TABLE 43.—*Quantity and value of Manganese-ore produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity in tons	Value f.o.b. at Indian ports (£)	Quantity in tons	Value f. o.b. at Indian ports (£)
Bihar—				
Singhbhum . .	18,454	31,833	19,112	52,080
Bombay—				
Panchmahal . .	19,654	33,903	17,771	48,426
Central Provinces—				
Balaghat . . .	135,992	250,452	184,776	532,771
Bhandara . . .	68,063	125,350	71,047	204,852
Chhindwara . .	2,728	5,024	2,860	8,246
Nagpur . . .	67,649	124,587	75,084	216.492
Madhya Bharat—				
Indore . . .	450	574	489	1,007
Madras—				
Vizagapatam . .	..	..	11,359	18,837
Sandur (Bellary Dt.) .	44,695	39,108	59,108	90,140
Mysore State (Shimoga) .	558	516	1,333	2,122
Orissa—				
Bonai . . .	22,151	26,029	21,993	42,337
Keonjhar . . .	66,656	78,321	53,162	102,337
Koraput . . .	2,000	1.850	5,700	9,073
Patna . . .	250	294	..	..
Rajasthan—				
Banswara . . .	1,734	1,604	2,082	3,314
TOTAL .	451,034	719,445 =Rs. 96,40,563	525,876	1,332,084 =Rs. 1,78,49,25

On the average about 85 per cent. of India's output of manganese-ore is exported abroad, and of the total exports more than 80 per cent. consists of first grade ore. Against 367,750 tons of manganese-ore exported in the year 1948, that of 1947 totalled 597,677 tons *vide* table 44. The decline in the export is stated to have been due, as in the case of chromite, to difficulties of transport. It will also be observed that in this export traffic the share of Madras port was the largest. From the table 45 it will be seen that by far the greater part of the exports was shipped to the U. S. A.

There is a steady consumption of manganese-ore in the iron and steel factories of India where its use is three-fold, *viz.*, for the manufacture of pig iron, steel, and ferro-manganese. A certain amount of ore is used in the glass industry and in the local manufacture of dry cells. Of the total production of manganese-ore during 1948, about 10 per cent. was consumed in the iron and steel industry for the manufacture of pig iron, steel and ferro-manganese. The details of consumption are given in table 46. A good proportion of the quantity consumed was used in making ferro-manganese. The quantity of ferro-manganese produced by the Tata Iron and Steel Co., dropped from 15,774 tons in 1947 to 6,604 tons in the year 1948. The Indian Iron and Steel Co., Ltd., produced 2,536 tons in 1948. There was no output of this metal by the latter firm in the previous year. There is room for considerable expansion of the manufacture of ferro-manganese which, it will be in the interests of the country to export as much as possible in lieu of raw ore. With low manganese-ore production costs and low fuel charges India will be well able to compete in this trade.

With the growth of iron and steel industry, in the country, the domestic consumption of manganese will thus gradually increase and the resources of this mineral will be adequate to meet the demands of the future even if the present surplus production is allowed to be exported for some years to come.

TABLE 44.—*Exports of Manganese-ore during the years 1947 and 1948 according to ports of shipment (in tons).*

—	1947	1948
Bombay	101,783	50,645
Calcutta	90,378	55,028
Madras	347,296	224,454
Mormugao (Portuguese India)	58,220	(a) 37,623
TOTAL	597,677	367,750

(a) Including 4,208 tons of Goan origin.

TABLE 45.—*Exports of Manganese-ore from Indian ports during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons	Rs.	Tons	Rs.
To—				
United Kingdom	60,885	30,68,585	69,443	43,03,149
U. S. A.	365,088	1,69,18,154	182,181	96,85,315
Other countries	113,484	46,33,331	78,503	46,57,255
TOTAL	539,457	2,46,20,070	330,127	1.86,45,719

TABLE 46.—*Consumption of Manganese-ore in the Iron and Steel industry of India during the years 1947 and 1948.*

—	1947	1948
Indian Iron and Steel Co., Ltd.	25,522	21,547
Tata Iron and Steel Co., Ltd.	49,939	28,338
Steel Corporation of Bengal	2,172	1,470
Mysore Iron & Steel Works	473	522
TOTAL .	78,106	51,877

Mica

There are two kinds of mica of commercial value—muscovite and phlogopite. Both are used in the electrical industry as insulators, but muscovite has a much wider use in radio tubes, condensers, furnace windows, etc. The crude mica is brought from the mines to the cutting sheds to be dressed into blocks and splittings. "Blocks" are made out of sheets rifted from the crude mica, cutting away the flaws. Most of the block mica of poorer qualities is converted into splittings. The larger sizes of splittings are assembled into book form, analogous to pack of cards. Splittings are then manufactured into micanite, the most important insulating material used in electricity by cementing the films with some suitable medium. Both block mica and micanite ore indispensable for the manufacture of the vital parts of electrical machinery or apparatus. Scrap mica is finely ground into powder used for rubber-filler, roofing, lubrication, etc.

India is the largest producer of muscovite block mica and mica splittings. Over 70 per cent. of the world's supply of dressed mica—blocks and splittings—comes from India and muscovite alone accounts for 80 to 90 per cent. India has extensive reserves of this mineral and the world markets have generally been controlled by the supply of Indian Mica, which comes chiefly from the Hazaribagh district of Bihar, the Nellore district of Madras and from several areas of Rajasthan. The phlogopite variety of mica is obtained from Travancore. India's mica mining is best developed in the Hazaribagh district where it is now being further improved on modern lines with the help of mechanical equipment. There was an appreciable increase in the production of mica from 136,308 cwts. valued at Rs. 1,81,84,020 in the year 1947 to 151,273 cwts. valued at

Rs. 1,86,13,907 in 1948. The mica fields of Hazaribagh and Gaya in Bihar and of Nellore in Madras were responsible for this increase, *vide* table 47. It may be pointed out that the production statistics generally relate to dressed mica, but they do not discriminate between blocks, splittings and scrap, as the export statistics do, the reason being that with the exception of a very few, the mining companies do not keep a close record of the percentages of the various qualities produced from each mine. The output figures are also incomplete and it is rather the export figures which provide a clearer picture of the actual production of the Indian mica mines, *vide* table 48. The difference between export and production figures can be explained by (1) export of stolen mica which does not appear in the production report, (2) export of legitimate mica from small concerns, which does not appear in recorded returns, and (3) export of mica recovered from dumps, scrap and waste mica.

The total value of mica exported from India rose from Rs. 4,65,89,163 in 1947 to Rs. 6,14,40,100 in 1948 with the U.S.A. as the biggest purchaser. This was a record figure so far. It is noteworthy that 2,791 cwts. of mica valued at Rs. 9,20,179 was also imported in 1948, presumably for re-exports after conversion into splittings.

Almost the whole quantity produced in India is exported abroad since very little is consumed in the country. Only a very small quantity of micanite is at present made in India. There is a small but steadily growing industry in the manufacture of washers, rings and condenser plates. Block mica about 1,000 cwts. a year is used in India. The future of the mica industry is dependent on:—

(1) the improvement of mining methods to keep down the prices in anticipation of competition with the foreign substitutes ;

(2) the setting up of definite standard grades of quality in order to compete in the foreign market with the mica from other countries ;

(3) the manufacture of micanite in India from splittings in order to obtain the maximum income from the country's resources ;

(4) the establishment of an electrical manufacturing industry in India.

TABLE 47.—*Quantity and value of Mica produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Cwts.	Rs.	Cwts.	Rs.
Ajmer-Merwara	5,964	8,69,799	6,215	8,38,495
Bihar—				
Bhagalpur	859	2,76,620	744	1,46,495
Gaya	8,554	11,97,048	10,275	11,99,851
Hazaribagh	75,821	1,01,68,318	79,215	1,12,49,580
Monghyr	2,198	2,09,184	2,546	1,65,168
Ranchi	3	..	..	..
Hyderabad	30	2,897	..	..
Madhya Bharat—				
Gwalior	180	41,476	396	75,000
Madras—				
Kistna	186	14,487	106	17,140
Madura	..	..	9	..
Nellore	13,604	6,83,262	21,730	10,58,914
Nilgiris	128	14,704	199	9,958
Travancore	140	31,400	548	211 775
Mysore—				
Hassan	75	825	540	4,243
Kolar	13	100	..	..
Mysore	45	600	..	..
Rajasthan—				
Jaipur	3,380	4,64,750	2,720	3,80,000
Kishangarh	7,800	7,80,000	2,020	2,02,000
Mewar	13,540	29,77,563	12,401	27,09,282
Shahpura	1,808	2,50,987	8,682	2,41,000
Tonk	1,980	2,00,000	2,827	2,95,000
Dongarpur	—	—	100	(a)
TOTAL	136,308	1,81,84,020	151,273	1,86,13,901

(a) Not available.

TABLE 48.—*Exports of Mica from India during the years 1947 and 1948.*

—	1947					
	Blocks		Splittings		Ground, scrap or waste	
	Quantity	Value	Quantity	Value	Quantity	Value
	Cwts.	Rs.	Cwts.	Rs.	Cwts.	Rs.
To—						
United Kingdom	10,402	92,90,776	60,499	1,56,17,758	5,279	29,173
Palestine	..	..	.	..	..	..
Pakistan—Eastern	..	..	..	..	..	..
Australia	330	4,30,729	822	94,460	1,280	7,228
Hongkong	..	..	..	..	..	..
New Zealand	83	1,12,198	..	..	..	..
Sweden	8	1,550	1,410	6,07,050	..	..
Germany	..	..	..	..	.	..
Netherlands	43	61,083	112	18,055	..	..
Iraq	..	..	1	3,037	..	..
Iran	..	.	..	..	..	..
China	..	..	20	425	11	250
Japan	..	..	..	..	..	..
U. S. A.	3,278	17,58,909	77,547	1,59,53,164	24,780	83,851
Canada	63	87,934	1,785	9,25,184	..	..
Belgium	82	68,802	1,112	2,79,621	..	..
Switzerland	4	10,433	166	30,433	..	..
Egypt	2	1,347	..	..	..	..
Morocco French Protectorate	..	..	..	..	..	..
France	2	6,000	2,310	5,98,861	..	..
Italy	55	16,058	1,345	5,49,799	..	..
Kuwait	.	..	..	..	..	..
TOTAL	14,292	1,17,90,810	147,079	3,46,77,842	31,300	1,20,502
Share of ports—						
West Bengal	..	..	..	..	..	..
Madras	11,296	85,75,564	126,166	3,00,09,738	31,299	1,20,499
Bombay	2,991	32,09,485	20,912	46,65,067	1	3
Sind	5	5,770	1	3,037	..	..
TOTAL	14,202	1,17,90,819	147,079	3,46,77,842	31,300	1,20,502

	1947
TOTAL quantity (Cwts.)	192,671
TOTAL value (Rs.)	4,65,89,163

TABLE 48.—*Exports of Mica from India during the years 1947 and 1948*—(contd.)

—	1948					
	Blocks		Splittings		Ground, scrap or waste	
	Quantity	Value	Quantity	Value	Quantity	Value
	Cwts.	Rs.	Cwts.	Rs.	Cwts.	Rs.
To—						
United Kingdom	7,621	50,52,896	50,372	1,03,90,419	59,464	3,38,155
Palestine	..	..	..	..	..	..
Pakistan—Eastern	..	..	..	120	..	..
Australia	416	4,68,181	877	1,09,069	320	1,920
Hongkong	44	8,306	1,422	3,68,358	..	..
New Zealand	54	50,062	..	.	..	..
Sweden	14	24,293	77	56,664	..	..
Germany	146	2,07 188	653	3,20,417	..	..
Netherlands	310	2,54,325	..	..	..	..
Iraq	..	..	1	2,150	..	..
Iran	..	..	..	..	..	..
China	41	1,430	..	..	80	2,520
Japan	790	6,60,300	986	3,71,945	172	48,975
U. S. A.	3,718	23,73,646	145,149	3,74,58,160	85,408	4,79,067
Canada	..	..	953	4,37,804	20	232
Belgium	57	84,726	1,253	5,31,292	3	1,500
Switzerland	..	..	293	98,965	..	..
Egypt	..	2,005	..	..	..	..
Morocco French Protectorate	10	9,707	10	6,347	..	..
France	167	1,60,850	166	5,94,551	..	..
Italy	105	50,919	506	3,57,736	..	..
Kuwait	..	..	200	4,000	..	..
TOTAL	13,488	94,09,784	202,920	5,11,57,997	145,467	8,72,369
Share of ports—						
West Bengal	8,397	64,30,626	162,426	4,43,98,169	123,895	7,40,299
Madras	5,076	29,78,783	40,293	67,53,678	21,572	1,32,070
Bombay	15	375	201	6,150	..	..
Sind	..	..	..	..	..	..
TOTAL	13,488	94,09,784	202,920	5,11,57,997	145,467	8,72.369

	1948
TOTAL quantity (Cwts.)	361,875
TOTAL value (Rs.)	6,14,40,100

Ochre

Ochres are coloured earths usually with ferric (red) and hydrated ferric (yellow) oxides. These substances are well known as mineral pigments or natural paints. Before marketing, most of the ochres have to be dried, ground and sieved. The occurrences of this mineral are fairly widespread in India, the chief producing areas being, the C. P., Vindhya Pradesh, Gwalior and Madras. Many small deposits are also worked from which production is not reported. The output of ochre dropped from 11,397 tons valued at Rs. 2,00,153 in 1947 to 10,557 tons valued at Rs. 2,86,809 in 1948. This drop in the total output was due to the production of this mineral from Kurnool having decreased considerably in the year under review.

The whole of the output is consumed in India for industrial purposes, and this consumption shows an increase from an average of about 7,000 tons in 1937 to 11,397 tons in 1947.

TABLE 49.—*Quantity and value of Ochre produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons	Rs.	Tons	Rs.
Central Provinces—				
Drug	56	198	..	..
Jubbulpore . . .	860	19,720	1,197	79,127
Kawardha . . .	..	..	..	..
Madhya Bharat—				
Gwalior	128	3,673	..	..
Madras—				
Kurnool	2,385	12,550	765	7,650
Trichinopolly (a) . .	35	120	100	300
Bellary (b) . . .	2,084	47,955	3,751	45,251
Mysore	1,667	33,560	73	1,730
Orissa—				
Mayurbhanj . . .	28	372	..	..

TABLE 49.—*Quantity and value of Ochre produced in India during the years 1947 and 1948*—(contd.)

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons	Rs.	Tons	Rs.
Rajasthan—				
Karauli	..	..	137	7,886
Jaisalmer	294	1,001	213	1,707
Vindhya Pradesh—				
Nagod	154	772	..	..
Panna	1,223	13,262	1,458	60,714
Sohawal	2,483	66,970	2,733	77,944
Kothi	..	..	130	4,500
TOTAL .	11,397	2,00,153	10,537	2,86,809

(*a*) Including Puddukottai State.
(*b*) Including Sandur State.

Petroleum

Crude oil is fractionally distilled ; the primary fractions tend to overlap and are re-distilled to give more complete separation. The lighter fractions yield aviation and motor spirits and some kerosene ; medium oils range from kerosene through Diesel oil to light lubricants (spindle oil, etc.) ; and the heavier oils are mainly lubricants, creosotelike dark oils, etc. Distillation residues include fuel oils and petroleum coke. Waxes are recovered from lubricating oil fractions, in which they are dissolved, by chilling and either pressure-filtration or centrifuging ; they occur in most types of crude oil except the heavier asphaltic oils, but are most abundant in paraffinic and mixed paraffinic-naphthenic types. Heavy residues from asphaltic, asphaltic-naphthenic, etc., types of crude oil yield a range of bitumens valuable as water-proofing and insulating materials; apart from use of their lighter part as fuel-oils, it may also be 'cracked' at high temperature and pressure, or under partial vacuum, or hydrogenated, or used with coal-dust in the Bergives process, to yield further supplies of the light fractions. 'Refining' strictly applies to the further processes, such as acid-washing, which the re-distilled products undergo in order to remove any undesirable polymers, sulphurous or other corrosive compounds, etc. The average annual world production of petroleum during the years 1941-46 was of the order of 400 million tons of which India's share is very insignificant—about ·006 per cent.

The rock formations with which petroleum is associated occur over wide areas in Assam, in Tripura, along the foot of the Himalayas and in Cutch and Kathiawar. But so far, North-Eastern Assam has been the only oil producing zone in the Indian Union. The oil fields of Assam are held under mining lease by the Assam Oil Co., Ltd. The Digboi field is the only successful field in Assam; the Badarpur field in the Surma Valley having been exhausted many years ago while the Masimpur and Patharia fields have yielded only small shows of oil and gas inspite of persistent drilling and prospecting of the last two decades.

During the year 1948, the production of Digboi field was maintained. New wells in the main field continued to give disappointing results and in order to keep up production a high level of drilling effort was required. Extension drilling at the Western end of the field gave no production, but at the Eastern end, one new well was successfully brought in with satisfactory production, giving indications of some additional productive acreage in this area. Well No. 17 was undertaken and at the end of the year had reached a depth of over 2,500′ without any favourable indications. Operations preparatory to drilling a test well were carried out at Tiru Hills involving a railway siding, making of roads through difficult country where a great deal of grading was required and erection of buildings, etc. At the close of the year work was sufficiently advanced to indicate that drilling operations would start about the beginning of July, 1949. Active preparations were made for the drilling of two very deep test wells at Masimpur (Cachar) and Rokhia (Tripura). The crude oil of Assam contains large proportions of gasoline, paraffin and naphthalene.

A quantity of 65,607,982 gallons of crude petroleum valued at Rs. 1,08,99,126 was produced from the Digboi field during 1948 against 65,192,235 gallons valued at Rs. 1,08,30,060 in 1947. The details of petroleum products obtained by the company at their refinery at Digboi are shown in table 50. The details of various grades of mineral oil imported are shown in the subsequent tables 51, 52, 53, 54. It will be seen that the total quantity of mineral oils imported into India during 1948 amounted to 480 million gallons, and that the bulk of the imports, *i.e.*, about 413 million gallons (86 per cent. of the total quantity) came from Iran and Bahrein Islands. Since the Seaborne Trade Accounts for 1948 include figures for the import trade of Pakistan up to 28th February, 1948, about 4 per cent. of these imports (on the basis of 20 per cent. for 12 months), *i.e.*, 19 million gallons may be reckoned as Pakistan's share. Allowing therefore 4 per cent. for Pakistan, the consumption in the Indian Union may be roughly estimated at 461 million gallons imported, plus 54 million gallons (excluding wax) produced, equal to 515 million gallons of which the production forms about 10 per cent. only. It is, therefore, obvious that more than 90 per cent. of India's requirements is met by imports from abroad. In these circumstances an intensive effort for exploration of India's petroleum resources is called for, to prove the workability of the known potential oilfields and to discover new fields by the latest improved prospecting practice. Meanwhile, India's dependence on the imports of fuel oils can be greatly minimised by the manufacture of synthetic petrol, etc., from lower grade coals of Bihar, and if sulphur content can be effectively removed, from the high volatile coals of Assam. Coal tar benzene, either alone or blended with industrial alcohol can also be utilised as motor spirit.

TABLE 50.—*Petroleum Products in Assam during the years 1947 and 1948 (in gallons).*

—	1947	1948
Motor spirit, etc	19,234,722	17,848,519
Kerosene	14,266,242	11,132,682
Distillate fuels	11,114,453	14,933,821
Wax	9,173,869	9,995,652
Bitumen	231,270	621,242
Sundry oils	6,909,092	8,027,543
Coke	2,379,841	2,096,911
TOTAL	63,309,489	64,656,320

TABLE 51.—*Imports of Kerosene Oil into India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Gallons	Rs.	Gallons	Rs
From—				
Iran	178,465,263	8,76,23,220	74,150,870	4,27,15,963
Bahrein Island . . .	18,739,666	1,04,09,118	10,912,252	1,24,36,117
Iraq	..	..	1	1
Other Countries .	623,216	3,19,307	6,943,511	46,96,455
TOTAL .	197,828,145	9,83,51,645	101,006,634	5,98,48,536

TABLE 52.—*Imports of Fuel Oil into India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Gallons	Rs.	Gallons	Rs.
From—				
Iran	285,417.006	6,29,01,375	168,425,223	4,33,74,352
Bahrein Island . . .	20,584,977	43,81,313	33,853,693	87,72,212
Other Countries . .	1,856,234	5,35,634	21,657,457	66,35,548
TOTAL .	307,858,217	6,78,18,322	223,936,373	5,87,82,112

TABLE 53.—*Imports of Motor Spirit into India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Gallons	Rs.	Gallons	Rs.
From—				
Iran	97,347,579	7,57,84,445	88,720,497	8,05,67,218
Bahrein Island . . .	6,607,046	46,47,901	17,365,221	1,43,49,760
U. S. A.	1,689,133	31,68,016	1,341	4,013
Burma	225	169	..	..
Other Countries . .	..	..	3,803,144	35,91,649
TOTAL .	105,643,983	8,36,00,531	109,890,203	9,85,12,640

TABLE 54.—*Imports of Lubricating Oil into India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Gallons	Rs.	Gallons	Rs.
From—				
Iran	(*a*)13,086,202	82,71,208	(*a*)10,735,797	68 44,033
United Kingdom .	2,252,742	45,78,659	2,550,748	64,64,731
U. S. A.	35,397,691	6,09,52,855	32,011,275	5,96,72,886
Other Countries . .	(*b*)326,301	5,90,195	(*c*)285,930	6,73,068
TOTAL .	51,062,936	7,43,92,917	45,583,750	7,36,54,718

(*a*) Batching oil.
(*b*) Including 16,746 gallons of Batching oil.
(*c*) Including 34,319 gallons of Batching oil.

TABLE 55.—*Exports of Paraffin Wax from India during the years 1947 and 1948.*

—	1947		1948	
	Quantity	Value	Quantity	Value
	Tons	Rs.	Tons	Rs.
To—				
United Kingdom . .	8,947	66,68,196	965	10,68,356
Union of South Africa .	..	..	..	..
Australia	3,115	27,49,756	4,319	49,89,563
Other Countries . .	3,788	29,98,870	6,689	71,95,332
TOTAL .	15,850	1,24,16,822	11,973	1,32,53,251

Rutile

This is a natural oxide of titanium and is thus far richer in titanium (60% TiO_2) than ilmenite, and more suitable for the preparation of titanium dioxide paints than ilmenite. It nowadays finds a special use in electric welding. It occurs in considerable quantities in ilmenite, monazite sands of the Travancore coast from which it is recovered in the zircon fraction. After magnetic separation the zircon is said to contain about 12 per cent. of rutile. It is also known to be plentiful in the kyanite rocks of Lapsa Buru, Singhbhum, but its separation is difficult. During the year 1948 an output of 127 tons valued at Rs. 24,925 was reported from Travancore against 157 tons valued at Rs. 30,858 in 1947. The whole of the output is exported abroad, mostly to U. S. A. and U. K.

Salt

Apart from its necessity in food, common salt is one of the fundamental raw materials of the chemical industry, as from it many sodium compounds are derived which are used in many other industries. The average annual world production of salt during 1940-46 is of the order of 35 million metric tons.

The salt produced in India is obtained from three principal sources (*a*) sea water, (*b*) lakes and sub-soil water in areas where the rivers have no outlet to the sea and (c) rock-salt beds. About two-thirds of the salt made in India are recovered from sea water, chiefly in Bombay, Madras and Orissa; about one-third from salt lakes in Rajasthan and sub-soil brine in the Ranns of Cutch and the rest from Bengal, Bihar and the U. P. including a small quantity of rock salt from Mandi in Himachal Pradesh. The salt from the inland lakes or from sea water is precipitated by solar evaporation of the salt solutions. Much of the salt produced in India is manufactured by the salt Department of the Central Government; a certain amount is manufactured by companies and private concerns.

There was appreciable increase in the production of salt in India from 1,540,353 tons valued at Rs. 2,46.89,794 in 1947 to 2,264,536 tons valued at Rs. 4,33,88,667 in 1948. Saurashtra, Bombay and Madras salt sources were responsible for this increase *vide* table 56.

During this year the production of rock salt in Mandi in Himachal Pradesh amounted to 4,058 tons valued at Rs. 1,78,798 against 4,532 tons valued at Rs. 1,76,229 in 1947. Exports of salt were negligible, a quantity of 8,590 tons being exported in 1948. There was a slight increase in the import of salt into India from 306,349 tons valued at Rs. 2,34,93,103 in 1947 to 345,576 tons valued at Rs. 2,37,85,766 in 1948, *vide* table 57. The quantity of salt available for consumption in India during this year was therefore 2,601,522 tons (2,264,536+345,576−8,590). The greater portion of the quantity available for consumption is used for domestic purposes, a very small percentage being utilized in industries. India is not quite self-sufficient in regard to this mineral and has, of necessity, to depend on imports from abroad to meet some portion, about 10 to 15% of her total internal requirements and particularly those of Bengal, which is largely supplied by foreign salt. But it is reassuring to find that there has been a steady rise in the indigenous production of salt during the last few years, and it is hoped that this gap between the production and consumption will be filled up when the various salt projects of the Government materialise in the near future.

TABLE 56.—*Quantity and value of Salt produced in India during the years 1947 and 1948.*

	1947		1948	
	Quantity	Value	Quantity	Value
	tons.	Rs.	tons.	Rs.
Bengal (West)	1,880	1,60,252	(*a*)	..
Bihar and U. P. . . .	1,201	1,12,761	.	..
Bombay	370,264	1,06,71,483	664,777	1,84,00,714
Kutch	..	..	64,529	12,90,580
Madras	628,147	88,82,556	812,047	1,59,70,363
Himachal Pradesh (Mandi State).	4,532	1,76,229	4,058	1,78,798
Rajasthan Salt Sources . .	497,152	41,78,391	432,966	36 62,924
Orissa	37,177	5,08,122	(*b*)22,384	(*c*)3,80,528
Saurashtra	..	.	263,775	(*c*)35,04,760
TOTAL .	1,540,353	2,46,89,794	2,264,536	4,33,88,667

(*a*) *See* Orissa. (*b*) Including West Bengal. (*c*) Estimated.

TABLE 57.—*Imports of Salt into India during the years 1947 and 1948.*

	1947		1948	
	Quantity	Value	Quantity	Value
	tons.	Rs.	tons.	Rs.
From—				
Aden and Dependencies .	129,000	98,58,787	205,341	1,39,78,359
Pakistan (Western) . .	..	..	40,092	28,10,434
Egypt	104,682	79,76,154	32,950	22,38,146
Other countries . .	72,667	56,58,162	67,193	47,58,827
TOTAL .	306,349	2,34,93,103	345,576	2,37,85,76

Saltpetre

Saltpetre occurs as a natural efflouresence in extensive areas in Bihar, the U. P. and the East Punjab. It is derived in a crude form by dissolving out the mixed salts contained in soil around villages and effecting a separation of the two most prominent salts sodium chloride (common salt) and potassium nitrate (Saltpetre). The amount of saltpetre in the soil varies from 1 to 29 per cent. but is generally less than 5 per cent. Some of the crude saltpetre so collected is used as manure, but most of it is sent to the refineries in India for the production of refined saltpetre by fractional crystallization.

Refined saltpetre is generally used in India in the manufacture of fire works, blasting powder, soap and matches and in ceramic and tanning industries. It is also used as a fertiliser in the tea gardens in India. Roughly 1,500 tons of saltpetre are used annually in the manufacture of gunpowder and blasting powder in India. A considerable quantity of saltpetre used to be exported from India in the past to the U. K., Ceylon, Mauritius and other countries, but during the last decade, its exports were gradually on the decline. This steady fall in the export is partly attributable to its increasing consumption in Indian industries.

Compared with the war years, the production too of saltpetre has come down to some extent in the recent years. This is obviously due to its lesser demand from munition industries. The production and export of saltpetre during the years 1947 and 1948 are shown in tables 58, 59, respectively.

TABLE 58.—*Quantity and value of Saltpetre produced in India during the years 1947 and 1948.*

—	1947.		1948.	
	Quantity.	(*a*)Value.	Quantity.	Value.
	Tons.	Rs.	Tons.	Rs.
East Punjab . . .	1,323	..	(*b*)177	3,58,500
U. P.	1,056	..	1,241	5,99,200
Madras	19	..	10	3,742
Patiala and E.P.S.U.—		..		
Patiala	1,471	..	(*c*)1,544	1,70,180
Jhind	184	..		
Nabha	61	..		
TOTAL .	4,114	..	2,972	11,31,622

(*a*) Not available. (*b*) incomplete figure. (*c*) Separate figures for individual States are not available.

TABLE 59.—*Exports of Saltpetre from India during the years 1947 and 1948.*

—	1947.		1948.	
	Quantity.	Value.	Quantity.	Value.
	Cwts.	Rs.	Cwts.	Rs.
To—				
United Kingdom . .	..	..	..	..
Ceylon . . .	519	24,830	230	21,508
Mauritius and Dependencies	..	..	..	..
Australia	98	3,200	..	..
Other countries . .	15,706	6,06,930	491	42,000
TOTAL	16,323	6,34,960	721	63,508

Silver

Apart from its use in coinage and silverware, silver has an extensive application in photography and recently in certain industrial alloys. More than half the world's production of silver is derived from ores which are primarily worked for lead, zinc, copper and only about one-third from ores in which silver is the principal valuable constituent. The average annual world production of silver during the year 1942-46 was about 188 million ozs. In India it is obtained from the treatment of the gold on the Kolar goldfields, Mysore. The output of silver as a by-product from the Kolar gold mines amounted to 12,797 ozs. valued at Rs. 60,299 in 1948 against 12,422 ozs. valued at Rs. 54,725 in the previous year.

The net imports of silver bullion and coin during the year 1948 were 4,619,917 ozs., valued at Rs. 2,06,49,725. The quantity of silver available for consumption in India during this year was therefore 4,632,714 ozs. (12797+4,619,917). India is obviously deficient in this metal and has, of necessity, to depend on its imports from abroad.

Steatite

Steatite or soapstone is well known as French Chalk. The purer form of steatite is used as a polishing medium, as a filler in paint, paper and textiles, and as a refractory in gas burners, etc. It is also used in the manufacture of soap, wall plaster, lubricants and for foundry facings. When required as refractory lining in furnaces, it is cut into blocks of the requisite size and shape, and when used as a filler in paper, etc., in lubricants or in ceramics, it must be ground to a fine powder in dry mills.

Deposits of steatite are widespread in India. They are known to occur in various localities in Bihar, the C. P., Madras, Mysore, Jaipur, Mewar, Ajmer-Merwara, the U. P., Kashmir, etc. Production is reported from all these areas, the most important of them being the Jubbulpore district of the C. P. and Jaipur. The output of steatite in 1948 amounted to 18,096 tons valued at Rs. 12,05,582 against 20,652 tons valued at Rs. 10,02,819 in the previous year. This decrease in the total output was due to the absence of production of this mineral from Mewar in the year 1948.

The bulk of the steatite produced is marketed in India while a considerable quantity is exported abroad. 3,683 tons of this material valued at Rs. 5,99,395 were shipped during the year, under review. India is however considered to be capable of supplying any demand for its use in the various industries of the country. At present it is chiefly used in Indian paper mills, rubber works, cable companies, chemical and soapworks, etc. A considerable quantity of this material is also consumed in India in making cooking utensils, pots, carvings, etc.

TABLE 60.—*Quantity and value of Steatite produced in India during the years 1947 and 1948.*

—	1947		1948	
	Quantity.	Value.	Quantity.	Value.
	Tons.	Rs.	Tons.	Rs.
Ajmer Merwara . . .	148	2,750	..	..
Bihar—				
Bhagalpur . . .	..	..	24	1,410
Hazaribagh . . .	640	25,600	639	35,000
Seraikela . . .	96	3,386	80	15,613
Singhbhum . . .	50	225	3	18

TABLE 60.—*Quantity and value of Steatite produced in India during the years 1947 and 1948*—(contd.)

	1947		1948	
	Quantity	Value	Quantity	Value
	Tons.	Rs.	Tons.	Rs.
Central Provinces—				
Bhandara	27	699	16	777
Drug	..	..	110	500
Jubbulpore	2,136	1,46,834	2,620	1,90,428
Kashmir	951	6,657	..	..
Madras—				
Anantapur	284	8,135	244	6,110
Kurnool	222	4,440	..	..
Nellore	563	5,000	30	1,800
Mysore	139	1,385	177	1,074
Orissa—				
Keonjhar	332	4,482	641	9,615
Nilgiri	..	..	107	633
Mayurbhanj	50	5,535	46	13,730
Rajasthan—				
Jaipur	12,248	6,12,400	13,298	9,19,010
Mewar	2,746	1,75,110	..	..
Alwar	..	..	15	600
United Provinces—				
Jhansi	20	181	..	..
Hyderabad	..	..	46	9,072
TOTAL	20,652	10,02,819	18,096	12,05,582

II. MINERAL CONCESSIONS

1. *Summary of the existing mineral concessions in India (excluding the States and States Unions) as on 31st December, 1948.*

Provinces(a).	Total No of Mineral Concessions existing in 1947.				Total No. of Mineral Concessions granted in 1948				Total No. of Mineral Concessions terminated in 1948				Total No of Mineral Concessions existing in 1948			
	Pros-Licenses	Mining	Quarry	Total.	Pros-Licenses	Mining	Quarry	Total	Pros-Licenses	Mining	Quarry	Total.	Pros-Licenses	Mining	Quarry	Total
Ajmer-Merwara	152	111	..	263	55	16	..	71	15	2	.	20	189	125		314
Assam	7	20	10	37	2	..	..	2	.	..	.		9	20	10	39
Bengal (West)	2	3	..	5	1	..	2	3	..	..	..	..	3	3	2	8
Bihar	..	(b)372	(b)46	(b)418	..	10	21	31	..	4	8	12		378	59	437
Bombay	(b)22	(b)23	61	(b)106	7	9	19	35	1	..	6	7	28	32	74	134
C. P. & Berar	57	266	475	798	36	9	129	174	6	3	6	15	87	272	598	957
Delhi	1	..	29	30	..	.	..	..	..	..	..	..	1	..	29	30
Madras	149	526	328	1,003	95	73	..	168	..	..	115	115	244	599	213	1,056
Orissa	16	68	1	85	..	1	..	1	..	1	..	1	16	68	1	85
United Provinces	4	4	—	8	1	..		1	..		.	..	5	4	..	9
TOTAL	410	1,393	950	2,753	97	118	171	186	25	10	135	170	582	1,501	986	3,069

(a) In provinces including merged States. (b) Revised.

MINERAL CONCESSION—*contd.*

2. Statement of Mineral Concessions granted and terminated during the year 1948.

Summary for Indian Union (including States and States Unions).

Provinces	Granted.			Total.	Terminated.			Total.
	Prospecting Licenses.	Mining Leases.	Quarry Leases.		Prospecting Licenses.	Mining Leases.	Quarry Leases.	
Ajmer-Merwara	55	16	..	71	18	2	..	20
Assam	2	..	..	2	..	..	..	..
Bengal (West)	1	..	2	3	..	..	..	..
Bihar	..	10	21	31	..	4	8	12
Bombay	7	9	19	35	1	..	6	7
C. P. & Berar	36	9	129	174	6	3	6	15
Madras	95	73	..	168	..	..	115	115
Orissa	..	1	.	1	..	1	..	1
United Provinces	1	..	.	1	..	..	..	..
Hyderabad	3	..	19	22	..	..	1	1
Kashmir	..	..	..	..	..	1	..	1
Madhya Bharat	1	2	..	3	..	..	..	..
Mysore	38	3	..	41	12	..	..	12
Patiala & East Punjab States Union.	..	2	..	2	..	1	.	1
Rajasthan	12	17	..	29	17	49	.	66
Vindhya Pradesh	6	5	..	11	3	..	..	3
TOTAL	257	147	190	594	57	61	136	254

CLASSIFICATION OF LICENSES AND LEASES

AJMER-MERWARA.

Prospecting Licenses and Mining Leases granted and terminated in Ajmer-Merwara during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			PROSPECTING LICENSES.			
Ajmer	6	7·95	Mica	1	1·36	Mica, Felspar Beryl. Quartz.
Do.	1	·21	Muscovite	1	2·38	Mica, Beryl.
Do.	1	18·53	Garnet, Soapstone, Aquamarine. Sapphire, Emerald.	1	8·42	Mica, Quartz, Soapstone.
Do.	1	1·36	Beryl, Mica, Felspar. Quartz	1	42·73	Mica, Kyanite, Beryl, Soapstone, Emerald, Ruby, Sapphire.
Do.	1	29·56	Ruby, Emerald, Kyanite, Sapphire & Aquamarine.	1	10·78	Mica, Asbestos, Soapstone.
Do.	2	13·91	Mica, Soapstone. Quartz	1	9·71	Beryl, Ruby, Kyanite, Emerald Sapphire, Aquamarine.
Do.	1	2·38	Mica, Beryl	1	14·58	Mica, Kyanite, Soapstone, Asbestos, Quartz, Beryl, Ruby, Sapphire, Emerald, Aquamarine.

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

AJMER-MERWARA—*contd.*

Prospecting Licenses and Mining Leases granted and terminated in Ajmer-Merwara during the year 1948—contd.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
Ajmer	1	23·15	Mica, Emerald	1	1·2	Mica
Do.	1	35·43	Mica, Quartz, Kyanite, Ruby, Soapstone, Emerald, Sapphire, Aquamarine.	1	23·84	Mica, Quartz, Asbestos, Soapstone Beryl, Ruby, Sapphire, Emerald, Aquamarine.
Do.	1	10·8	Quartz, Soapstone, Beryl, Emerald, Asbestos, Ruby, Sapphire & Aquamarine.	..	..	....
Do.	1	7·18	Beryl, Bauxite, Emerald, Asbestos, Aquamarine, Kyanite, Mica, Ruby, Sapphire.	..	..	....
Do.	1	38·25	Mica, Graphite, Kyanite, Soapstone, Ruby, Emerald, Sappheri, Asbestos, Aquamarine.	..	..	....
Do.	1	11·25	Beryl, Soapstone, Garnet, Emerald, Sapphire, Aquamarine.	..	.	
Do.	1	5·62	Mica, Kyanite, Soapstone, Ruby, Emerald, Sapphire.	..		.

Do.	3	10·83	Mica, Felspar . . .	..	..	
Do.	1	9·14	Mica, Quartz, Felspar . . .	..	..	.
Do.	1	10·78	Mica, Asbestos, Soapstone . .	..	..	.
Do.	1	23·9	Mica, Quartz, Asbestos, Soapstone, Beryl, Ruby, Emerald, Sapphire, Aquamarine.	..	..	..
Do.	1	9·71	Beryl, Ruby Emerald, Kyanite, Sapphire, Aquamarine.	..	..	...
Do. . . .	1	14·58	Mica, Kyanite, Soapstone, Asbestos, Quartz, Beryl, Sapphire, Ruby, Emerald, Aquamarine.	..	..	....
Do. . . .	1	42·73	Mica, Kyanite, Beryl, Soapstone, Emerald, Ruby, Sapphire.	..	..	....
Do.	1	18·46	Mica, Kyanite, Soapstone, Quartz, Beryl, Ruby, Emerald, Sapphire.	..	..	....
Do.	1	11·6	Calcite, Garnet, Soapstone, Beryl, Emerald, Sapphire.	..	..	....
eawar	5	32·05	Mica, Felspar	2	13·21	Mica.
Do.	3	20·65	Mica, Quartz, Felspar . . .	2	9·38	Mica, Beryl.
Do.	10	42·63	Mica	2	6 65	Mica, Felspar.
Do.	2	12·00	Mica, Felspar, Quartz, Beryl .	2	12·00	Mica, Felspar, Quartz, Beryl.
Do.	2	9·38	Mica, Beryl	1	1·72	Mica, Quartz, Felspar, Asbestos, Soapstone, Beryl.

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

AJMER-MERWARA—*concld.*

Prospecting Licenses and Mining Leases granted and terminated in Ajmer-Merwara during the year 1948—concld.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
Beawar	1	1·72	Mica, Quartz, Felspar, Asbestos, Soapstone, Beryl.		.	. . .
Kekri	1	·76	Mica	..	..	....
TOTAL .	55			18		
			MINING LEASES.			
Ajmer	5	33·65	Mica, Felspar	..	..	....
Do.	3	3·39	Mica	..	..	....
Do.	2	19·46	Mica, Felspar, Quartz . . .	..	..	..
Beawar	2	1·74	Mica	1	·18	Mica, Beryl, Felspar.
Kekri	4	(*a*)	Mica	1	(*a*)	Mica
TOTAL .	16			2		

(*a*) Not available.

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

ASSAM.

Prospecting Licenses and Mining Leases granted and terminated in Assam during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
Sibsagar	1	2304	Petroleum	..	..	....
Do.	1	3200	Coal	..	..	....
TOTAL .	2					

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

WEST BENGAL.

Prospecting Licenses and Quarry Leases granted and terminated in West Bengal during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			PROSPECTING LICENSES.			
arjeeling . . .	1	1200	Coal	..	..	....
Total .	1					
			QUARRY LEASES.			
alpaiguri . . .	2	480	Limestone	..	..	....
Total .	2					

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

BIHAR.

Quarry Leases and Mining Leases granted and terminated in Bihar during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			QUARRY LEASES.			
Santhal Parganas . .	15	370·92	Stone Meterial	2	28·32	Stone material.
Do.	1	1·55	Soap soil	2	46·88	Stone.
Do.	2	40·87	Stone	..	..	....
Singhbhum . . .	2	39·70	Limestone	1	7·00	Limestone.
Do.	1	58·50	Slate Stone	1	80	Ballast
Do.	..	..	....	1	40	Quartzite.
Do.	..	..	....	1	60·80	Slate Stone.
TOTAL .	21			8		

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

BIHAR—*concld.*

Quarry Leases and Mining Leases granted and terminated in Bihar during the year 1948—concld.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			MINING LEASES			
Santhal Parganas . .	6	12·32	Coal	2	219·76	Limestone.
Do. . . .	..	..	....	1	77·54	Chromite.
Shahabad . . .	2	219·78	Limestone	..	..	...
Singhbhum . .	1	1228	Iron & Manganese ore . . .	1	500	Chromite.
Do. . . .	1	500	Chromite	..	..	....
TOTAL .	10			4		

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

BOMBAY.

Prospecting Licenses, Mining Leases and Quarry Leases granted and terminated in Bombay during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			PROSPECTING LICENSES.			
Belgaum . . .	2	18·15	China clay	..	..	....
Panch Mahals . . .	1	..(a)	Manganese ore, Copper, Jalvatin. Antimony.	..	..	....
Do.	1	309·17	Galva ore	..	..	...
Ratnagiri . . .	1	9·12	Mica	1	9·12	Mica.
Sabarkantha . . .	1	..	Mica	..	..	....
Do. . . .	1	..	Asbestos	..	..	...
TOTAL .	7			1		
			MINING LEASES.			
Kaira	1	51,911·48	Limestone and clay . . .	..	..	....
Kanara	1	67	Asbestos	..	..	....
Panch Mahals . . .	1	579·1	Manganese-Ore	..	..	...
Do. . . .	1	(a)	Manganese ore Jalvatin, copper, Antimony	..	..	....
Ratnagiri . . .	1	178·12	Mica	..	..	....

(a) Not available.

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

BOMBAY—*concld.*

Prospecting Licenses, Mining Leases and Quarry Leases granted and terminated in Bombay during the year 1948—concld.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			MINING LEASES—*contd.*			
Sabarkantha	1	290	Pipe-clay	..	..	....
Do.	1	..	Sand, Kankar, Metal . . .	..	..	....
Do.	1	640	Mica	..	..	....
Surat	1	114	Metal	..	..	....
TOTAL .	9					
			QUARRY LEASES.			
Dharwar . .	3	·06	Stone, Slabs	..	..	....
Panch-Mahals . . .	1	8·47	Kankar, Brass	..	..	....
Do.	1	48·52	Stone	..	..	....
Sabarkantha . . .	1	..	Grinding stone	..	..	....
Do. . . .	1	..	Sandstone	..	..	....
Do. . . .	2	·04	Black Stone and Metal . . .	..	..	....
Satara South . . .	4	·08	Black stone and Metal . . .	6	·72	Black Stone and Metal.
Surat	5	19·37	Metal	..	..	....
Do.	1	..	Stones	..	..	....
TOTAL .	19			6		

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

CENTRAL PROVINCES AND BERAR.

Prospecting Licenses, Mining Leases and Quarry Leases granted and terminated in Central Provinces and Berar during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			PROSPECTING LICENSES.			
Surat	1	640·00	Clay	..	..	....
Do.	1	18·00	Mica	..	..	....
Chhindwara	..	..	....	3	425·97	Coal.
Do.	..	..	....	2	19·53	Felspar.
Hoshangabad	1	81·12	Soapstone and Marble	1	799·19	Coal.
Jubbulpore	1	14·53	Hematite and Red Ochre	..	..	....
Do.	1	77·90	Soapstone and Hematite	..	..	....
Do.	1	35·00	Oxide of iron	..	..	....
Do.	12	494·76	Soapstone	..	..	....
Do	2	39·12	Hematite, Clay, Marble, Quartz	..	..	....
Do.	1	20·00	Soapstone, Limestone, Dolomite and Quartz.	..	..	....

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

CENTRAL PROVINCES AND BERAR—*contd.*

Prospecting Licenses, Mining Leases and Quarry Leases granted and terminated during the year 1948—contd.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			PROSPECTING LICENSES—*contd.*			
Jubbulpore	1	40·30	Barytes, Dolomite	..	..	....
Do.	1	51·10	Whiteclay	..	..	....
Do.	1	4·59	Limestone and Soapstone	..	..	....
Do.	1	77·38	Soapstone and Marble	..	..	....
Do.	7	252·91	Limestone	..	..	....
Do.	1	27·28	Fire clay	..	..	....
Do.	1	51·29	Yellow Ochre	..	..	....
Yeotmal	2	456·16	Limestone	..	..	....
TOTAL	36			6		

			MINING LEASES.			
Chhindwara	6	1,465·06	Coal	1	44.38	Calcite.
Do.	..	..	....	2	374·80	Coal.
Jubbulpore	1	42·50	Barytes	..	..	....
Do.	1	24·01	Bauxite	..	..	....
Nagpur	1	118·37	Manganese ore	..	..	....
TOTAL	9			3		
			QUARRY LEASES.			
Balaghat	1	3·00	Limestone	..	..	....
Do.	4	5·97	Clay	..	..	....
Do.	1	3·00	Limestone	..	..	....
Betul	1	25·00	Pottery Clay and Sandstone	..	..	....
Bhandara	1	5·43	Flooring stone	..	..	....
Do.	1	2·30	Clay	..	..	....
Do.	1	5·90	Soapstone	..	..	...
Bilaspur	1	4·00	Limestone	1	3·43	Limestone.
Do.	13	37·04	Clay	..	..	....
Do.	1	4·00	Limestone	..	..	....
Do.	1	7·69	White Clay	..	..	....
Chanda	2	22·50	Yellow Ochre	1	11·25	Yellow ochre.
Do.	1	44·00	White Ochre	1	104·98	Sand.

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

CENTRAL PROVINCES AND BERAR—*concld*

Prospecting Licenses, Mining Leases and Quarry Leases granted and terminated in Central Provinces and Berar during the year 1948—concld.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			QUARRY LEASES—*contd.*			
Chanda	1	31·65	Pottery clay	..	..	....
Do.	1	4·00	Stones	..	..	....
Chhindwara . . .	2	8·05	Limestone	1	3·58	Limestone.
Do. . . .	1	1·00	Clay	1	7·92	Felspar.
Do.	1	7·92	Felspar	..	..	....
Hoshangabad . . .	..	..	....	1	2·00	Soapstone.
Jubbulpore . . .	1	12·04	Red Ochre	..	..	....
Do.	21	135·10	Clay	..	..	....
Do.	3	50·23	Soapstone	..	..	....
Do.	9	180·24	Limestone	..	..	....
Do. . .	1	12·00	Soapstone and Marble . . .	..	..	....
Do.	1	11·56	White clay . . .	..	..	....

Do.	2	32·53	Stone and Clay	..	..	....
Do.	1	25·34	Barytes and Soapstone	..	..	....
Do.	2	2·00	Red stone	..	..	....
Do.	1	23·39	Soapstone, Calcite, Marble, Quartz	..	..	....
Do.	1	41·00	Stone and Murrum	..	..	....
Mandla	1	1·00	Limestone	..	..	....
Nagpur	26	200·92	Clay	..	..	...
Do.	4	40·77	Limestone	..	..	....
Do.	7	56·74	Clay & Sand	..	..	....
Do.	1	·80	Murrum	..	..	....
Do.	1	4·30	Faranda and Khandki	..	..	....
Do.	1	16·45	Murrum, Boulders, Rubble and Metal	..	..	....
Do.	1	2·00	White clay	..	..	....
Do.	1	24·46	Sand	..	..	....
Raipur	1	4·10	Limestone	..	..	....
Do.	2	17·94	Clay	..	..	....
Do.	1	4·00	Sand	..	..	....
Do.	1	13·53	Building Stone	..	..	....
Yeotmal	3	31·29	Limestone	..	..	....
TOTAL	129			6		

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

MADRAS.

Prospecting Licenses and Mining Leases granted and terminated in Madras during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
Anantapur	16	264·39	Barytes	..	..	....
Do.	5	141·10	Steatite	..	..	....
Do. . . .	1	16·23	Barytes and Soapstone . . .	..	..	....
Do.	1	7·14	China clay	..	..	....
Bellary .	1	640	Oxide of Iron, Iron Ores. Red Earth Ochres	..	..	....
Cuddapah . .	1	25·58	Asbestos	..	..	....
Do.	43	678·03	Barytes	..	..	....
Do.	1	9·50	Yellow Ochre . . .	..	..	....
Kurnool . . .	13	243·42	Barytes	..	..	....
Do.	2	20·00	Steatite	..	..	....
Nellore	10	245·11	Mica	..	..	....
Nilgiri	1	15·76				
Total .	95			..	..	....

			MINING LEASES.—			
Anantapur	12	290·18	Barytes	..	..	.
Do.	3	31·66	Yellow Ochre	..	..	..
Do.	1	41·75	Steatite	..	..	....
Do.	1	2·34	Kaolin and Felspar	..	..	....
Do.	1	32·00	Asbestos	..	..	....
Bellary	1	130	Red Earth Ore, Oxide of Iron	..	..	....
Do.	1	259·37	Manganese Ore	..	..	....
Cuddapah	1	74·51	Barytes and Asbestos	..	..	....
Do.	7	70·18	Barytes	..	..	....
Do.	2	17·48	China Clay	..	..	....
Do.	2	11·34	Yellow Ochre	..	..	...

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

MADRAS—*concld.*

Prospecting Licenses and Mining Leases granted and terminated in Madras during the year 1948—concld.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			MINING LEASES—*contd.*			
Guntur	1	(*a*)	Slabs	..	..	....
Do.	1	(*a*)	Red Ochre	..	..	....
Kurnool	15	452·90	Barytes	..	..	....
Do.	3	11 60	Yellow Ochre	..	..	....
Do.	2	52·91	Barytes and Red Oxide of Iron .	..	..	....
Do. . . .	2	108·37	Slate Stone	..	..	....
Do.	6	83·38	Yellow Ochre and White shale	..	..	....
Nellore . . .	7	134·03	Mica	..	..	....
South Arcot . . .	1	6·72	White Clay	..	..	....
Do.	1	8·65	China Clay	..	..	....
Tinnevelly . . .	1	·32	Garnet, Sand . . .	..	..	....
Trichinopoly . . .	1	77·43	Celestite	..	..	....
TOTAL .	73			..		
Pudukottai	..		QUARRY LEASES	114	620·84	Granite.
Do.	..		....	1	10·00	Limestone.
				115		

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

ORISSA.

Mining Leases granted and terminated in Orissa during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
Mayurbhanj State .	1	220·73	Soapstone and Mica . . .	..	..	....
Sundergarh . . .	..	..	....	1	349·13	Manganese ore.
TOTAL .	1			1		

UNITED PROVINCES

Prospecting Licenses granted and terminated in United Provinces during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
Garhwal	1	1,300	Sulphates, Carbonates phosphates and Silicates.	..	..	. . .
TOTAL .	1					

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

HYDERABAD.

Prospecting Licenses and Quarry Leases granted and terminated in Hyderabad during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
Gulbarga	1	20	Felspar	..	..	....
Warangal	1	1,731	Coal	..	..	...
Do.	1	2,240	Garnets	..	..	....
TOTAL .	3					.

QUARRY LEASES.

Adilabad	5	150·5	White clay	1	63	White clay.
Aurangabad	5	(*a*)	Building stones	..	..	....
Bidar	1	(*a*)	Red Ochre	..	..	....
Gulbarga	2	86	Limestone	..	..	....
Karimnagar	1	(*a*)	Do.	..	..	....
Do.	2	4	Steatite	..	..	....
Mahbubnagar	1	(*a*)	Mill stones	..	..	....
Raichur	1	(*a*)	Limestone	..	..	...
Warangal	1	(*a*)	Building stones	..	..	....
TOTAL	19			1		

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

KASHMIR.

Mining Leases terminated in Kashmir during the year ending 31st December, 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
Doda	..	..	....	1	216	Sapphire.
			TOTAL .	1		

MADHYA BHARAT.

Prospecting Licenses and Mining Leases granted and terminated in Madhya Bharat during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			PROSPECTING LICENSES			
Barwani State . .	1	640	Manganese ore	..	..	....
TOTAL .	1					
			MINING LEASES			
Jobat	1	(*a*)	White clay	..	..	....
Do.	1	(*a*)	Black clay	..	..	....
TOTAL .	2					

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

MYSORE.

Prospecting Licenses and Mining Leases granted and terminated in Madras during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			PROSPECTING LICENSES			
Bangalore	1	325	Kaolin, Quartz, Feldspar	1	960	Kaolin.
Do.	1	980	Kaolin	..	..	....
Hassan	1	1,920	Soapstone, Corundum, Kyanite, Staurolite, Graphite, Asbestos.	1	1,280	Corundum.
Do.	..	..	....	1	1,920	Soapstone, Corundum, Kyanite, Staurolite, Graphite and Asbestos.
Do.	1	1,280	Corundum	..	..	....
Do.	1	640	Kyanite	..	.	....
Do.	1	960	Mica	..	..	....
Do.	1	2,560	Staurolite	1	2,560	Staurolite.
Kolar	2	1,920	Ochres	2	640	Kaolin.
Do.	1	320	Agate	1	320	Corundum, Garnet and Coal.
Do.	1	2,560	Mica, Garnet and Corundum	..	..	....

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

MYSORE—*concld.*

Prospecting Licenses and Mining Leases granted and terminated in Mysore during the year 1948—concld.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			PROSPECTING LICENSES—*contd.*			
Kolar	3	960	Kaolin	1	320	Agate-Quartz and Amethyst.
Do.	1	640	Chrome and Magnesite . . .	..	..	....
Do.	1	640	Corundum	..	..	...
Do.	1	1,280	Corundum and Garnet . . .	..	..	....
Mandya	1	320	Asbestos	..	..	....
Mysore	3	1,920	Chrome	1	640	Mica and Garnet.
Do.	2	960	Chrome and Magnesite . . .			
Do.	1	640	Corundum	.	..	...
Do.	1	640	Mica and Garnet	.	..	....
Do.	1	320	Ruby and Corundum . . .	..	..	...
Do. . . .	3	1,280	Asbestos	..	..	....
Do.	1	1,920	Mica	..	..	....
Do.	1	320	Dolomite and Limestone . .	..	..	....
Do.	1	320	Chromite	..	..	....

Tumkur	1	320	Quartz, Quartzite and Manganese dioxide.	1	2,560	Corundum.
Do.	1	1,280	Rock Crystals	2	(a)	Soapstone.
Do.	1	1,280	Kaolin	..	..	....
Do.	1	1,280	Ochres	..	..	....
Do.	2	..	Soapstone	..	..	....
TOTAL .	38			12		
			MINING LEASES.			
Bangalore . . .	1	80	Kaolin	..	..	....
Do.	1	80	Quartz	..	..	....
Mysore	1	137	Chrome	..	..	....
TOTAL .	3			..		

PATIALA AND EAST PUNJAB STATES UNION

Mining Leases granted and terminated in Patiala and East Punjab States Union during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
Dhanauri . . .	..	..	....	1	170	Lead.
Mashuta . .	1	..	Barytes	..	..	....
Surajpur . .	1	..	Limestone, Shales and Gypsum .	..	..	....
TOTAL .	2			1		

(a) Not available.

CLASSIFICATION OF LICENSES AND LEASES—*contd.*

RAJASTHAN

Prospecting Licenses and Mining Leases granted and terminated in Rajasthan during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			PROSPECTING LICENSES.			
Alwar	2	320	Soapstone and Calcite	..	..	....
Banswara	..	..	....	2	2,100	Galena.
Jaipur	2	(*a*)	Emerald	..	..	....
Jodhpur	..	..	....	1	640	Yellow Ochre.
Do.	..	..	....	1	80	Red Ochre.
Do.	..	..	....	1	35	Black Ochre.
Kishangarh	..	..	....	1	92·4	Mica.
Sirohi State	1	1,276,160	Mica	..	..	....
Do.	1	384,000	China clay	..	..	....
Do.	1	384,000	Soapstone	..	..	....
Udaipur	3	9,600	Emerald	4	16,000	Emerald.
Do.	1	896,000	Mica	2	6,400	Corundum.
Do.	1	10 miles radius around Eklingji temple.	Soapstone and Talc Steatite	1	(*a*)	Lead, Zinc and Silver.
				1	..	Mica.
				1	1,440	Garnet.
				1	1,280	Garnet and Kyanite.
				1	3,200	Blue Sapphire.
TOTAL	12			17		

			MINING LEASES.			
Dungarpur	1	Whole of the Dungarpur Dt.	Precious and Semi-precious Stones .	..	..	. .
Jaipur	12	2,560	Mica	2	1,280	Silica.
Do.	..	..	....	1	1,920	White clay & Red Ochre.
Do.	..	..	....	3	2,240	Red Ochre.
Do.	..	..	....	1	160	Glass Sand.
Do.	..	..	....	12	7,610	Mica.
Do.	..	..	....	5	6,400	Clay.
Do.	..	..	....	15	11,680·91	Limestone.
Do.	..	..	....	1	1,920	White clay.
Do.	..	..	....	4	2,240	Yellow Ochre.
Do.	..	..	....	4	2,560	Soapstone.
Karauli	1	(a)	Red Ochre	..	..	....
Do.	1	(a)	Silica	..	..	....
Do.	2	(a)	Yellow Ochre	..	..	....
Udaipur	..	..	....	1	Whole of Sub dt. Bhim.	Mica.
TOTAL .	17			49		

(a) Not available.

CLASSIFICATION OF LICENSES AND LEASES—*concld.*

VINDHYA PRADESH

Prospecting Licenses, Mining Leases and Quarry Leases granted and terminated in Vindhya Pradesh during the year 1948.

District.	Granted.			Terminated.		
	No.	Area in acres.	Mineral.	No.	Area in acres.	Mineral.
			PROSPECTING LICENSES.			
Sohawal	6	139	Ochre	3	45	Ochre.
TOTAL	6			3		
			MINING LEASES.			
Kothi	1	15	Ochre	..	..	....
Rewa	2	2,295·47	Coal	..	..	....
Do.	1	414·26	Limestone	..	..	....
Do.	1	354·2	Corundum	..	..	....
TOTAL	5			..		

DETAILS OF MINERAL CONCESSIONS GRANTED

Statement of Mineral Concessions granted during the year ending 31st December, 1948.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
		AJMER-MERWARA				
Ajmer . . .	(1) Mr. Rang Lal Sethi, Sanod	Mica	P. L.	·9	29-3-48	6 months.
Do. . . .	(2) Mr. Ladoo Lal Kataria, Nasirabad.	Mica and Felspar . . .	M. L.	·65	5-2-48	3 years.
Do. . . .	(3) Mr. Keshav Lal D. Dave, Ajmer.	Muscovite	P. L.	·21	10-4-48	1 year.
Do. . . .	(4) Mr. R. V. Durlabhji, Ajmer	Garnet, Soapstone, Aquamarine, Sapphire, Emerald.	P. L.	18·53	24-4-48	Do.
Do. . . .	(5) Messrs. Jivraj Bhanji & Co., Ajmer.	Mica, Felspar, Quartz, Beryl .	P. L.	1·36	23-2-48	4 months (Extension).
Do. . . .	(6) R. B. Seth, Sir Bhagchand Soni, Ajmer.	Ruby, Emerald, Sapphire, Kyanite, Aquamarine.	P. L.	29·56	6-5-48	1 year.
Do. . . .	(7) Mr. L. Kalyanmal Tak, Ramsar.	Soapstone, Quartz, Mica . .	P. L.	8·42	7-2-48	6 months.
Do. . . .	(8) R. B. Seth, Sir Bhagchand Soni, Ajmer.	Mica, Beryl	P. L.	2·38	17-3-48 (Renewal).	Do.

P. L.=Prospecting License.
M. L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
		AJMER-MERWARA—*contd.*				
Ajmer . . .	(9) Mr. Gopilal Bakliwal, Ramsar.	Mica	M. L.	1·38	28-5-48	3 years.
Do. . . .	(10) Messrs. Behari Lal, Shyamsunder Lal and Co., Nasirabad.	Do.	M. L.	·74	25-5-48	5 years.
Do. . . .	(11) Mr. Nemi Chand Sethi, Sanod.	Do.	M. L.	1·27	12-5-48	3 years.
Do. . . .	(12) Sri Sanwarmal Mansinghka, Bhilwara.	Mica, Emerald . . .	P. L.	23·15	4-6-48	1 year.
Do. . . .	(13) Sir Bhag Chand Soni, Ajmer.	Mica, Quartz, Kyanite, Ruby, Soapstone, Emerald, Sapphire, Aquamarine.	P. L.	35·43	2-7-48	Do.
Do. . . .	(14) Shri Ladoo Lal Sethi, Sanod.	Mica	P. L.	1·25	14-7-48	Do.

Do.	(15) Sir Bhagchand Soni, Ajmer	Mica, Graphite. Kyanite, Soapstone, Ruby, Emerald, Sapphire, Asbestos and Aquamarine.	P. L.	38·25	28-7-48	Do.
Do.	(16) Do.	Mica. Asbestos, Bauxite, Beryl, Emerald. Ruby, Sapphire, Kyanite and Aquamarine.	P. L.	7·18	Do.	Do.
Do.	(17) Do.	Quartz, Soapstone, Emerald, Beryl, Asbestos, Ruby, Sapphire and Aquamarine.	P. L	10·8	Do.	Do.
Do.	(18) Messrs. R. V. Durlabhji, Alwar Gate, Ajmer.	Beryl, Soapstone. Garnet, Emerald, Sapphire and Aquamarine.	P. L.	11·25	29-7-48	Do.
Do.	(19) Do.	Mica, Kyanite, Soapstone, Ruby, Emerald and Sapphire.	P. L.	5·62	Do.	Do.
Do.	(20) Sir Bhagchand Soni, Ajmer	Mica, Asbestos, Soapstone	P. L.	10·78	17-7-48 (Renewal).	Do.
Do.	(21) Do.	Mica, Quartz, Asbestos, Soapstone, Beryl, Ruby, Emerald, Sapphire and Aquamarine.	P. L.	23·9	Do.	Do.
Do.	(22) Do.	Beryl, Ruby, Emerald, Kyanite, Sapphire, Aquamarine.	P. L.	9·71	3-9-48 (Renewal).	Do.
Do.	(23) Do.	Mica, Kyanite, Soapstone, Asbestos, Quartz, Beryl, Sapphire, Ruby, Emerald and Aquamarine.	P. L.	14·58	Do.	6 months.
Do.	(24) Do.	Mica, Kyanite, Beryl, Soapstone, Emerald, Ruby, Sapphire.	P. L.	42·73	27-8-48	1 year.

P. L.=Prospecting License.
M. L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
		AJMER-MERWARA—*contd.*				
Ajmer . .	(25) Messrs. R. V. Durlabhji, Alwargate, Ajmer.	Calcite, Garnet, Soapstone, Beryl, Emerald, Sapphire.	P. L.	11·6	16-8-48	1 year.
Do. . . .	(26) Seth Ranglal Sethi, Sanod	Mica	P. L.	2·26	25-8-48	Do.
Do. . . .	(27) Sir Bhagchand Soni, Ajmer	Mica, Quartz, Soapstone . .	P. L.	5·49	26th Aug. '48	Do.
Do. . . .	(28) Messrs. Inderchand Rajgarhia & Sons, Kekri.	Mica, Felspar . . .	M. L.	10·58	15-7-48	5 years.
Do. . . .	(29) Jivraj Bhanji & Co., Ajmer	Mica, Felspar, Quartz . .	M. L.	1·87	26-7-48	Do.
Do. . . .	(30) Shri Ranglal Sethi, Mica Merchant, Sanod, P. O. Nasirabad.	Mica	P. L.	·76	5-10-48	1 year.
Do. . . .	(31) Shri Ladu Lal, Kataria, Mica Merchant, Nasirabad.	Mica, Felspar . . .	P. L.	3·9	2-11-48	Do.

Do. . . .	(32) Shri Panchulal Sethi, Mica Merchant, Sanod, P. O. Nasirabad.	Mica . . .	P. L.	1·2	7-10-48	4 mont
Do. . . .	(33) Seth Sobhagmal Lodha, Lodha House, Ajmer.	Do. . .	P. L.	1·58	June '48 (Renewal).	1 year
Do. . . .	(34) Mr. Sahib Chand Surana, Beawar.	Mica, Felspar . . .	P. L.	1·25	20-3-48	Do.
Do. . . .	(35) Do. . .	Do. . .	P. L.	5·68	10-3-48	Do.
Do. . . .	(36) Messrs. Jivraj Bhanji & Co., Ajmer.	Mica, Quartz, Felspar . .	P. L.	9·14	30-4-48	Do.
Do. . . .	(37) Messrs. Inder Chand Rajgarhia & Sons, Kekri.	Mica, Felspar . . .	M. L.	12·9	22-12-47	3 year
Do. . . .	(38) Do. . .	Do.	M. L.	7·4	24-3-46	5 year
Do. . . .	(39) Abdul Ghani & Co. . .	Do.	M. L.	2·12	13-12-47	Do.
Do. . . .	(40) R. B. Seth, Sir Bhag Chand Soni.	Mica, Kyanite, Soapstone. Quartz, Beryl, Ruby, Emerald, Sapphire.	P. L.	18·46	28-12-47	1 year.
Do. . . .	(41) R. B. Shivratan G. Mohatta	Mica, Felspar, Quartz . .	M. L.	17·59	2-9-47	5 year
Beawar. . .	(42) Mr. Sahib Chand Surana, Beawar.	Mica, Felspar . . .	P. L.	·97	10-3-48	6 mont
Do. . . .	(43) Messrs. Jivraj Bhanji & Co., Ajmer.	Mica, Quartz Felspar . .	P. L.	6·3	30th April, '48	1 year.
Do. . . .	(44) Do. . .	Do.	P. L.	13·76	Do.	Do.
Do. . . .	(45) Mr. Ramballabh Agarwal, Beawar.	Mica	P. L.	2·08	Do.	Do.

P. L.=Prospecting License.
M. L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
		AJMER-MERWARA—*concld.*				
Beawar	(46) Shamlal Pragnarain, Ajmer	Mica, Felspar. Quartz, Beryl	P. L.	8·74	30-5-48	6 months (Extension).
Do.	(47) Ladulal Kataria, Nasirabad	Mica, Felspar	P. L.	2·1	24-5-48	1 year.
Do.	(48) Sahib Chand Surana, Beawar	Do.	P. L.	1·78	27-5-48	Do.
Do.	(49) Do.	Do.	P. L.	24·42	Do.	Do.
Do.	(50) Messrs. Bhattacharya & Sons, Ajmer.	Mica and Beryl	P. L.	8 14	10-3-48 (Renewal).	8 months
Do.	(51) Messrs. Bhattacharya Mining Corporation, Ajmer.	Mica, Quartz, Felspar, Asbestos, Soapstone, Beryl.	P. L.	1·72	8-5-48 (Renewal).	6 months.
Do.	(52) Shri Girdharilal, Beawar	Mica	P. L.	2·52	9-8-48	1 year.
Do.	(53) Shri Ramballabh Agarwal, Beawar.	Do.	P. L.	6·76	10-8-48	Do.
Do.	(54) Shri R. D. Joshi, Mewari Bazar, Beawar.	Mica, Felspar, Quartz	P. L.	·59	28-8-48	Do.

Do.	(55) Shri Vishnu Chandra, Prop., Chandra Stores, Ajmer.	Mica	P. L.	1·5	1-9-48	Do.
Do.	(56) Shri Akbarali Rajabali, Udaipur.	Mica, Beryl	P. L.	1·24	4-8-48 (Renewal).	6 months.
Do.	(57) Shri Sahib Chand, Surana	Mica, Felspar	P. L.	2·78	10-9-48	1 year.
Do.	(58) Shiv Ratan G. Mohatta, Ajmer.	Mica	P. L.	6·84	15-3-48	Do.
Do.	(59) J. K. Soneji	Mica, Felspar, Quartz. Beryl	P. L.	3·26	22-9-48	6 months.
Do.	(60) Shri Ramballabh Agarwal, Mica Mine Owner, Beawar.	Mica	P. L.	6·37	3-7-48 (Renewal).	1 year.
Do.	(61) L. Goverdhan Lal Rathi, Mica Merchant, Nasirabad.	Do.	P. L.	5·22	27-10-48	Do.
Do.	(62) Sri R. D. Joshi, Mewari Bazar, Beawar.	Do.	P. L.	1·6	3-11-48	Do.
Do.	(63) Messrs. Bhattacharya Mining Corporation, Beawar Road, Ajmer.	Do.	P. L.	8·14	10-10-48 (Renewal).	4 months.
Do.	(64) Sri Khem Singh Bhandari, Madan Gopal Building, Keshargunj, Ajmer.	Do.	M. L.	·54	10-11-48	3 years.
Do.	(65) Sri Vishnu Chandra, Prop., Chandra Stores, Ajmer.	Do.	P. L.	1·6	3-11-48	1 year.
Do.	(66) Mr. Sahib Chand Surana, Beawar.	Do.	M. L.	1·2	11-5-47	3 years.
Kekri	(67) Mr. Nemi Chand Sethi, Sanod.	Do.	M. L.	(*a*)	(*a*)	Do.

(*a*) Not reported.
P. L.= Prospecting License.
M. L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

District.	Grantee.	Mineral.	Nature. of grant.	Area in acres.	Date of commencement.	Term.
		AJMER-MERWARA—*concld.*				
Kekri . . .	(68) Gangabishan Maheshwari, Ajmer.	Mica	M. L.	(*a*)	(*a*)	5 years.
Do. . . .	(69) Sri Sri Bux of Jaipur, Kekri	Do.	M. L.	(*a*)	(*a*)	Do.
Do. . . .	(70) Sri Chouthmal Bhanwar Lal Kabra, Mine Owners, Kekri.	Do.	P. L.	·76	13-10-48	1 year.
Do. . . .	(71) Messrs. Labh Chand & Co., Kekri.	Do.	M. L.	(*a*)	16-10-48	5 years.
		ASSAM				
Sibsagar .	(72) Burmah Oil Coy., Ltd., P. O. Masimpur, Dt. Cachar.	Petroleum . . .	P.L.	2,304	9-4-48	2 years.
Do.	(73) Mr. D. D. Lohia of Messrs. Senairam Doongar Mull, 173, Harrison Road, Calcutta.	Coal . . .	P. L.	3,200	22-11-48	1 year.

WEST BENGAL

Darjeeling	(74) Sriram Brahma Dutt	Coal	P. L.	1,200	10-12-48	1 year.
Jalpaiguri	(75) Shri P. K. Roy	Limestone	Q. L.	320	24-9-48	5 years.
Do.	(76) Shri Nalini Ranjan Goswami	Do.	Q. L.	160	3-12-48	Do.

BIHAR

Santhal Parganas	(77) Messrs. Chatterjee Shaw & Co.	Stone Material	Q. L.	63·45	1-4-47	3 years.
Do.	(78) Do.	Do.	Q. L.	19·51	Do.	Do.
Do.	(79) Seth Nerajmall Hirdoymal	Do.	Q. L.	7·50	Do.	Do.
Do.	(80) B. N. Sett & Bros.	Do.	Q. L.	35·53	1-4-45	Do.
Do.	(81) Sha Md. Biswas	Do.	Q. L.	14·89	1-4-46	Do.
Do.	(82) P. K. Sarkar	Do.	Q. L.	64·19	Do.	Do.
Do.	(83) Nanji Manji	Do.	Q. L.	23·33	Do.	Do.
Do.	(84) Do.	Do.	Q. L.	3·40	Do.	Do.
Do.	(85) Sha Md. Biswas	Stone	Q. L.	8·70	1-1-48	Do.
Do.	(86) Nanji Manji	Do.	Q. L.	23·32	1-4-48 (Renewal).	Do.
Do.	(87) Do.	Do.	Q. L.	45·06	Do.	Do.

(*a*) Not reported.
P.L.=Prospecting License.

M.L.=Mining Lease.
Q.L. =Quarry Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
		BIHAR—*contd.*				
Santhal Parganas	(88) K. L. Bhagat	Stone	Q. L.	5·00	1-4-48 (Renewal).	3 years.
Do.	(89) Rameshwar Prasad	Soap Soil	Q. L.	1·55	1-1-48	Do.
Do.	(90) Mr. S. K. Kanjilal	Stone	Q. L.	37·25	1-4-46	Do.
Do.	(91) Nanji Manji	Do.	Q. L.	16·21	Do.	Do.
Do.	(92) S. K. Kanjilal	Do.	Q. L.	3·58	1-12-46	Do.
Do.	(93) Lachman Hansdh	Coal	M. L.	4·17	1-4-48	2 years.
Do.	(94) Debi Prasad Marwari.	Do.	M.L.	2·34	Do.	Do.
Do.	(95) Babu Jagarnath Bhagat	Do.	M. L.	·3	26-7-48	Do.
Do.	(96) Do.	Do.	M. L.	1·12	31-7-48	1 year.
Do.	(97) Babu Khudiram Seal	Do.	M. L.	2·15	Do.	2 years.

Do.	(98) Babu Kuar Marandi	Do.	M. L.	2·24	1-10-48	Do.
Do.	(99) Nanji Manji	Stone	Q. L.	39·32	1-4-48 (Renewal).	3 years.
Do.	(100) S. K. Kanjilal	Do.	Q. L.	1·55	1-1-48	Do.
Shahabad	(101) Messrs. Dalmia Jain and Co.	Limestone	M. L.	1·37	1-4-48	1 year.
Do.	(102) Do.	Do.	M. L.	82·76	Do.	Do.
Singhbhum	(103) Babu Thakur Prasad	Ghooting Limestone	Q. L.	6·20	8-2-48	5 years.
Do.	(104) Babu B. N. Biswas	Limestone	Q. L.	33·50	11-1-48	Do.
Do.	(105) Babu Chunilal Sharma	Slate Stone	Q. L.	58·50	30-4-48	Do.
Do.	(106) Indian Iron & Steel Co., Ltd.	Iron and Manganese ore	M. L.	12·28	8-3-48 (Renewal).	..
Do.	(107) Sir Indra Singh	Chromite	M. L.	500	27-1-48 (Renewal).	..

BOMBAY

Belgaum	(108) The Ceramic Products Ltd., Khanapur.	China Clay	P. L.	9·4	27-9-48	Do.
Do.	(109) Mr. A. K. Savant	Do.	P. L.	8·75	3-11-48	1 year.
Dharwar	(110) Gadigepgouda Dodmani	Stone slabs	Q. L.	·04	1946-47 (Renewal).	5 years.
Do.	(111) Parsappa Wadder	Do.	Q. L.	·02	Do.	Do.
Do.	(112) Irappa Sidramappa Waddar	Do.	Q. L.	(a)	1-8-48	1 year.

P. L.=Prospecting Licence.
M. L.=Mining Lease.

Q. L.=Quarry Lease.
(a) Not reported.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
		BOMBAY—*condt.*				
Kaira . . .	(113) The Associated Cement Co., Ltd., Bombay.	Limestone and Clay . .	M. L.	51,911·48	1-4-47	30 years.
Panara . .	(114) Mr. A. N. Mallapur, Bombay	Asbestos	M. L.	67	19-5-48	10 years.
Panchmahals .	(115) The Shivrajpur Syndicate Ltd.	Manganese-ore . . .	M. L.	579·1	1 12-45	12 years.
Do. .	(116) Jayant Lead Mining Corpn., Ltd.	Manganese-ore, Jalvatin copper, Antimony.	P. L.	(*a*)	27-8-47.	1 year.
Do. . .	(117) Morarji Jaganath . .	Kankar, Brass . . .	Q. L.	8·47	14-9-48	9 months.
Do. . .	(118) Sunder Minerals Ltd. .	Galva ore	P. L.	309·17	26-1-48	1 year.
Do. . .	(119) Mani Lal Maneklal . .	Stone	Q. L.	48·52	1-1-48	5 years.
Do. . .	(120) Sunder Minerals Ltd. .	Manganese-ore, Jalvalin, Copper, Antimony	Q. L.	(*a*)	16-12-48	Do.
Ratnagiri . .	(121) Messrs. Balkrishna Das & Co., Kharghat, Bombay.	Mica	P. L.	9·12	30-11-48 (Renewal).	1 year.
Do. . .	(122) Sawantwadi Minerals and Trading Co., Ltd., Kudal.	Do.	M. L.	178·12	27-1-48	30 years.
Sabar Kantha .	(123) Messrs. Somanath and Sons Ltd., Ahmedabad.	Pipe clay	M. L.	2·90	1-1-48	99 years.
Do. . .	(124) Thakaram Saheb Galbaba of Hapa.	Sand, Kakar and Metal . .	M. L.	(*a*)	31-1-48	5 years.
Do. . .	(125) Luhar Devkran Pana of Vavadi.	Grinding Stone . . .	Q. L.	(*a*)	16-2-48	1 year.

P. L.=Prospecting License.
M. L.=Mining Lease.
Q. L.=Quarry Lease.
(*a*) Not reported.

Do.	126) Hind Mica Works	Mica	M. L.	6·40	6-3-48	years
Do.	(127) Daud Amada of Ilol	Sandstone	Q. L.	(a)	18-7-48	1 year
Do.	(128) Kantilal J. Patel Ahmedabad and Benera Rajkumar Manginghji	Mica	P. L.	(a)	1-8-47	Do.
Do.	(129) Pioneer Magesia Works, Kharagpoda.	Asbestos	P. L.	(a)	1-10 46	2 years
Do.	(130) Nivrathi Tukaram Patil	Black Stone & Metal	Q. L.	·02	6-11-48	1 year
Do.	(131) Keshavrao Ganpatrao Jadhav.	Do.	Q. L.	·02	Do.	Do.
Satara South	(132) Maruti Ganpat Kokate	Do.	Q. L.	·02	Do.	Do.
Do.	(133) Bala Laxman Kalkutki	Do.	Q. L.	·02	Do.	Do.
Do.	(134) Gafar Babaji Bhokare	Do.	Q. L.	·02	Do.	Do.
Do.	(135) Laxman Gopal Jadhar	Do.	Q. L.	·02	Do.	Do.
Surat	(136) Messrs. R. Desai & Co.	Metal	M. L.	114	1-8-46	5 years
Do.	(137) Messrs. Dhanraj J. Parmar and Hiralal Raichand Udwada Stone Supply Co.	Do.	Q. L.	1·95	Do.	30 years
Do.	(138) Messrs. Gokaldas Vasanji & Co.	Do.	Q. L.	3·95	Do.	Do.
Do	(139) Mr. Gordhanbhai Muljibhai Patel.	Do.	Q. L.	5	1-8-47	5 years
Do.	(140) Messrs. Sayaji Iron Works Co.	Do.	Q. L.	1	Do.	1 year
Do.	(141) Mr. Mohanlal Harjiwandas	Do.	Q. L.	7·47	Do.	Do.
Do.	(142) Mr. Anant Vishnu Dandekar	Stones	Q. L.	(a)	Do.	Do.

Q. L.=Quarry Lease.
M. L.=Mining Lease.

(a) Not available.
P. L.=Prospecting License.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

CENTRAL PROVINCES AND BERAR

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat . .	(143) Shri Jairam Kheta Rathore, Balaghat.	Limestone	Q. L.	3·00	23-5-48	5 years
Do. . .	(144) Shri Bharat Lal Kripalal Kayasth of Mohgaon.	Clay	Q. L.	4·00	2-8-48	Do.
Do. . .	(145) Shri Upasya, Mohadi .	Do.	Q. L.	0·82	30-8-48	Do.
Do. . .	(146) Shri Brij Lal Waraseoni .	Do.	Q. L.	0·57	22-12-47	1 year
Do. . .	(147) Shri Hajarilal Waraseoni .	Do.	Q. L.	0·58	Do.	Do.
Do. . .	(148) Shri Jairam Kheta Rathore, Balaghat.	Limestone	Q. L.	3·00	2-11-47	10 years
Betul . . .	(149) Messrs. H. V. Kale & R. V. Deshmukh of Ellichpur. Chinhware.	Pottery clay and sandstone .	Q. L.	25·00	24-10-47	5 years
Bhandara . .	(150) Shri Sadasheo Tanbaji Khabragade of Tumsar.	Flooring stone . . .	Q. L.	5·43	23-11-48	Do.

Do.	(151) Shri Kalyanji Vitha Das Kunwarji Pacha, Gondia.	Clay	Q .L.	2·30	22-12-47	Do.
Do.	(152) Shri Maroti, Kunbi	Soapstone	Q. L.	5·90	28-7-46	10 years
Bilaspur	(153) Parbat Gangoo	Clay	Q. L.	1·87	15-1-48	5 years
Do.	(154) Shri Uttam Singh	Do.	Q. L.	6·92	24-2-47	10 years
Do.	(155) Shri D. N. Shukla	Building Stone	Q. L.	5·52	24-6-47	5 years
Do.	(156) Nankooram Kumhar	Clay	Q. L.	3·11	23 3-48	Do.
Do.	(157) Ramdhun Dube	Do.	Q. L.	1·17	24-4-48	10 years
Do.	(158) P. A. Banwar	Do.	Q. L.	3·00	11-5-48	5 years
Do.	(159) Shri Bhayadeen	Do.	Q. L.	1·64	18-5-48	Do.
Do.	(160) Nathanial Mistri	Do.	Q. L.	3·00	29-5-48	Do.
Do.	(161) Karam Chand	Do.	Q. L.	1·55	18-8-48	3 years
Do.	(162) Shri Lala Pindi Das	Limestone	Q. L.	4·00	4-10-48	10 years
Do.	(163) Messrs. Shesh Brothers	Clay	Q. L.	1·94	4-11-48	5 years
Do.	(164) Lala Pindi Das	Do.	Q. L.	2·47	8-12-47	Do.
Do.	(165) Shri Mahabir Prasad Khaitan	White clay	Q. L.	7·69	20-12-47	10 years
Do.	(166) Shri Gurudattamal	Clay	Q. L.	2·05	23-12-47	Do.
Do.	(167) Karam Chand	Do.	Q. L.	3·32	25-12-47	2 years
Do.	(168) Shri Bisnath Satnami	Do.	Q. L.	5·00	21-12-47	3 years

Q. L.=Quary Lesse.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

CENTRAL PROVINCES AND BERAR—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chanda . .	(169) Mohammad Hussain R. Hashamabhoy, General Merchant, Chanda.	Yellow Ochre	Q.L.	11·25	17-6-48 (Renewal).	..
Do. . .	(170) Do.	White Ochre	Q.L.	44·00	7-7-48	10 years
Do. . .	(171) Do.	Pottery Clay	Q.L.	31·65	8-7-48	Do.
Do. . .	(172) Sadasheo Pandurang Kunbi of Vijasan, Chanda.	Stones	Q.L.	4 00	28 6-48	6 years
Do. . .	(173) Mohammad Hussain R. Hashambhoy, General Merchant, Civil Lines, Chanda.	Yellow Ochre	Q.L.	11·25	17-6-48	10 years
Do. . .	(174) The Central Potteries Ltd., Itwari, Nagpur.	Clay	P.L.	640·00	4-8-48	1 year
Do. . .	(175) Chanda Trading Co., Chanda	Mica	P.L.	18·00	22-11-48	Do.
Chhindwara . .	(176) The Amalgamated Coal fields, Ltd., Parasia.	Coal	M.L.	440·22	4-6-48	17 years
Do. . .	(177) The Pench Valley Coal Co. Ltd., Parasia.	Do. . . .	M.L.	442·68	Do.	24 years

Do.	(178) Shri Mavji Raja, Chhindwara.	Limestone	Q.L.	4·60	24-9-48	5 years
Do.	(179) Shri Kushiram Lamba, Chhindwara.	Clay	Q.L.	1·00	4-2-48	2 years
Do.	(180) The Amalgamated Coalfields Ltd., Parasia.	Coal	M.L.	56·63	19-2-47	28 years
Do.	(181) Shri N. H. Ojha & Co., Ltd., Calcutta.	Do.	M.L.	79·26	Do.	16 years
Do.	(182) Shri R. S. Peshora Singh Sial, Nagpur.	Do.	M.L.	248·54	25-11-48	17 years
Do.	(183) Shri Oke Brothers, Nagpur	Felspar	Q.L.	7·92	21-3-48	4 years
Do.	(184) Shri Buddheolal Jagannath, Panara, Post Office Junnordeo, Dt. Chhindwara.	Coal	M.L.	197·73	31-8-48	10 years
Do.	(185) Shri Ganshyam Malguzar of Mankughuti.	Limestone	Q.L.	3·45	2-8-48	Do.
Hoshangabad	(186) Seth Sukhdeo Prasad	Soapstone and marble	P.L.	81·12	4-10-48	1 year
Jubbulpore	(187) Late Shrimati S. K. Chowhan, Jubbulpore.	Hematite and Red Ochre	P.L.	14·53	22-1-48	Do.
Do.	(188) Thakur Brijlal Singh, Katni	Soapstone and Hematite	P.L.	77·90	6-3-48	Do.
Do.	(189) Shri Ram Kishore Paroha, Govt. Contractor, Katni.	Red Ochre	Q.L.	12·04	11-10-47	10 years
Do.	(190) Seth Narsinghdass Hanumantal Jubbulpore.	Clay	Q.L.	4·57	Do.	Do.

P L.=Prospecting License.
Q.L =Quarry Lease

M. L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December. 1948—contd.

CENTRAL PROVINCES AND BERAR—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore .	(191) Shri R. K. Misra, Contractor, Sadar Bazar, Jubbulpore.	Stone and Clay . . .	Q.L.	31·12	1-10-47	5 years
Do. . .	(192) Sreemati Janak Dulari .	Limestone	Q.L.	2·00	30-8-45	10 years
Do. . .	(193) Shri S. N. Tandon Modholal, Jubbulpore.	Clay	Q.L.	6·00	1-3-47	2 years
Do. . .	(194) Shri Poparam Kumhar, Lalmiti, Jubbulpore.	Do.	Q.L.	1·50	23-10-47	3 years
Do. . .	(195) Mamta Kumari Chowhan, Jubbulpore.	Soapstone, Calcite, Marble, Quartz.	Q.L.	23·39	19-2-47	20 years
Do. . .	(196) Shri Dyers Stone Lime Co., Ltd., Katni.	Limestone	Q.L.	71·65	1-7-47	10 years
Do. . .	(197) Shri Releram Melaram of Maihar, Mg. Prop. Diwan Lime Co , Katni.	Do.	Q.L.	25·70	13-11-47	Do.
Do. . .	(198) Shri Baijnath Prasad Shrivastava, Contractor. Lalmitti, Ghamapur, Jubbulpore.	Clay	Q.L.	1·00	26-6-47	3 years

Do. . .	(199) Shri S. N. Tandon, Manmohan Nagar, Jubbulpore.	Stone and Murrum . .	Q.L	41·00	15-12-47	5 years
Do. . .	(200) Seth Lachminarayan, Rampratap, Sehora.	Oxide of iron	P.L.	35·00	10-3-48	1 year
Do. .	(201) Messrs. Modi Chowhan and Co., Jubbulpore.	Hametite, clay, marble and quartz.	P.L.	32·62	15-3-48	Do.
Do. . .	(202) Do. . . .	Do.	P.L.	6·50	31-3-48	Do.
Do. . .	(203) Thakur Birendra Singh, Katni.	Soapstone, Limestone, dolomite and quartz.	P.L.	20·00	14-4-48	Do.
Do. . .	(204) The Bir Mineral Supply Co., Katni.	Soapstone	P.L.	3·80	11-5-48	Do.
Do.	(205) Shri Shankerlal Goenka, Katni.	Do.	P.L.	15·00	(a)	Do.
Do. . .	(206) Shri P. V. Dutt, Lordganj, Jubbulpore.	Barytes and dolomite . .	P.L.	40·30	15-6-48	Do.
Do. . .	(207) Shri P. S. Sial and Sons, Nagpur.	Soapstone . . .	P.L.	91·57	14-9-48	Do.
Do. . .	(208) Shri Narsinghdas Jankidas Mohta of Umaria.	White clay . . .	P.L	51·10	21-6-48	Do.
Do. . .	(209) The Bir Mineral Supply Co., Katni.	Soapstone	P.L.	50·23	23-8-48	Do.
Do. . .	(210) Shri Ramdas Mahadeo Prasad of Jubbulpore.	Do. . .	P L.	44·00	16-9-48	Do.
Do. . .	(211) Shri Kedar Prasad Agarwal, Katni.	Do. . . .	P.L.	22·71	6-10-48	Do.

(a) Not available.
P.L.=Prospecting License.
Q.L.=Quarry Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

CENTRAL PROVINCES AND BERAR—*contd.*

District	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore	(212) Shri Ramdas Mahadeo Prasad of Jubbulpore.	Soapstone	P.L.	61·15	16-9 48	1 year
Do.	(213) Shri Sheonath Rai Contractor, Jubbulpore.	Do.	P.L.	10·90	11-3-48	Do.
Do.	(214) Shrimati Premlata Bhatnagar of Jubbulpore.	Limestone and Soapstone	P.L.	4·59	(*a*)	Do.
Do.	(215) Shri Sharda Prasad Shrivastava, Ghamapur, Jubbulpore.	Soapstone	P.L.	12·00	(*a*)	Do.
Do.	(216) Shri Modi Chowhan & Co., Jubbulpore.	Soapstone & Marble	P.L.	77·38	(*a*)	Do.
Do.	(217) Shrimati Premlata Bhatnagar, 181, Napier town, Jubbulpore.	Soapstone	P.L.	37·31	(*a*)	Do.
Do.	(218) Do.	Do.	P.L.	122·18	(*a*)	Do.

Do. . .	(219) Dyerstone, *Lime* Co., Katni	Limestone	P.L.	69·52	(*a*)	Do.
Do. . .	(220) The Indian Hume Pipe Co., Ltd., Jubbulpore.	Fire clay	P.L.	27·28	(*a*)	Do.
Do. . .	(221) Shri Kalloolal Gupta, Station Road, Rambhandar, Katni.	Limestone	P.L.	25·82	(*a*)	Do.
Do. . .	(222) Shri Gangadhar Rameshwardass, Katni.	Do.	P.L.	26·59	(*a*)	Do.
Do. . .	(223) Dr. S. L. Nigam, Katni	Do.	P.L.	63·74	(*a*)	Do.
Do. . .	(224) Shri L. N. Gupta, Katni .	Do.	P.L.	28·10	(*a*)	Do.
Do. .	(225) Shri Nathoolal Goenka, Katni.	Do.	P.L.	25·17	(*a*)	Do.
Do. . .	(226) Shri Bhaironath Chaturvedi, Lime Works, Katni.	Do.	P.L.	13·97	(*a*)	Do.
Do. .	(227) Shri Govind Prasad, Rajgond, Gangasagar (Garha), Jubbulpore.	Clay	Q.L.	1·00	10-4-48	3 years
Do. . .	(228) Shri N. A Parkar. Station Road, Katni.	Soapstone	Q.L.	10·00	13-5-48	5 years
Do. . .	(229) Shri Beohai Rampratap Singh, Contractor. Sathiyakua, Jubbulpore.	Clay	Q.L.	2·69	21-4-48	3 years
Do. . .	(230) Shri Baboo Badri Prasad, Contractor, Bheldarpura, Jubbulpore.	Do.	Q.L.	0·30	13-5 48	1 year

P.L.=Prospecting License.
Q.L.=Quarry Lease.

(*a*) Not available.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

CENTRAL PROVINCES AND BERAR—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore.	(231) Shri A. P. Pande, Agent, Oriental Life Office, Sihora.	Limestone	Q.L.	1·00	15-5-48	10 years
Do.	(232) Shri Lala Tulsiram Galgalatal, Tahsil, Jubbulpore.	Clay	Q.L.	0·50	13-5-48	Do
Do.	(233) Shri Ramdas Mahadeo Prasad, North Civil Lines, 74, Jubbulpore.	Yellow Ochre	P.L.	51·29	(*a*)	1 year
Do.	(234) The United Minerals Ltd., Calcutta.	Soapstone	P.L.	23·91	(*a*)	Do.
Do.	(235) Shri Phoolchand, Village Katra Baitla, Jubbulpore.	Clay	Q.L.	0·50	6-3-48	Do.
Do.	(236) Shri Beohar Raghubir Singh, Sathiyakua Jubbulpore.	Do.	Q.L.	1·00	10-4-48	3 years

Do. . .	(237) Shri Rameshwar Rao Gaikwad, 493, Napier Town, Jubbulpore.	Do.	Q.L.	1·54	28-1-48	5 years
Do. . .	(238) Shri Choudhri Tej Singh Ratan Chand Jain, Lordganj, Jubbulpore.	Clay	Q.L.	1·00	31-5-48	Do.
Do. . .	(239) Shri S. P. Goinka, Hanumanganj, Katni.	Limestone	Q.L.	8·55	1-6-48	10 years
Do. . .	(240) Shri Gajraj Kumhar, Jubbulpore.	Clay	Q.L.	1·00	24-6-48	1 year
Do. . .	(241) Shri Pritam Singh Sohi, Mining Contractor, P. O. Bahmanwara, Hirdagarh (G. I. P. Rly.), Chhindwara.	Soapstone . . .	Q.L.	34·73	30-3-48	7 years
Do. . .	(242) Shri Thakur Singh, Malguzar, P. O. Tewar, Jubbulpore.	Soapstone and Marble . .	Q.L.	12·00	25-6-48	10 years
Do. . .	(243) Shri Baboolal Kumhar. Gohalpur, Jubbulpore.	Clay	Q.L.	1·00	27-6-48	1 year
Do. . .	(244) Shri Chunnilal, Contractor, Bheraghat, P. O. Tewar, Jubbulpore.	Soapstone	Q.L.	5·50	27-7-48	10 years
Do. . .	(245) Shri Amarnath Bhaskar, Managing Director, Ishwar Industries, Niwar.	White clay	Q.L.	11·56	25-6-48	Do.
Do. . .	(246) Shri Parasnath Ghamapura, Jubbulpore.	Clay	Q.L.	2·00	Do.	3 years
Do. . .	(247) Shri Badri Prasad, Ghamapur, Jubbulpore.	Do.	Q.L.	1·00	21-6-48	Do.

(a) Not available.
P. L.=Prospecting License.
Q. L.=Quarry Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

CENTRAL PROVINCES AND BERAR—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore . .	(248) Shri Battilal Lodhi, Maharajpur, Gangasagar, P. O. Garha, Jubbulpore.	Stone and Clay . . .	Q.L.	1·41	24-6-48	5 years
Do. . .	(249) Shrimati Barki Kumharin, Bhatta Mohalla, Katni.	Clay	Q.L.	3·00	8-10-48	1 year
Do. . .	(250) Shri Gangadhar Rameshwardass, Katni.	Limestone	Q.L.	18·43	Do.	10 years
Do. .	(251) Shri G. H. Cook and Sons, Katni.	Barytes	M.L.	42·50	29-9-48	Do.
Do. . .	(252) Shri Rameshwardas, Katni	Limestone	Q.L.	17·46	17-11-48	Do.
Do. . .	(253) The Perfect Pottery & Co., Ltd., Jubbulpore.	Clay	Q.L.	1·00	8-10-48	5 years
Do. . .	(254) Do. . . .	Do.	Q.L.	1·50	20-10-48	Do.
Do. . .	(255) Shri Kedar Prasad Agarwal, Katni.	Soapstone and Barytes . .	Q.L.	25·34	29-4-48	10 years

Do.	(256) Shri S. P. Goenka, Hanumanganj, Katni.	Limestone	Q.L.	27·56	5-7-48	Do.
Do.	(257) Shri Pandit Chakorilal Pathak and Sons, Katni.	Bauxite	M.L.	24·01	3-8-48	Do.
Do.	(258) Shri Bhagirath Prasad, Lordganj, Jubbulpore.	Clay	Q.L.	3·00	1-11-48	5 years
Do.	(259) Shri Ramzan Khan, Gohalpur, Jubbulpore.	Do.	Q.L.	190	8-8-48	1 year
Do.	(260) Messrs. T. C. Bajan & Co., Lime Works, Katni.	Limestone	Q.L.	7·89	13-12-48	10 years
Do.	(261) Shri Damodardas Gupta. Purani Basti, Katni.	Redstone	Q.L.	1·00	9-12-48	5 years
Do.	(262) Do.	Do.	Q.L.	1·00	17-11-48	Do.
Mandla	(263) Gunaram	Limestone	Q.L.	1·00	9-5-48	Do.
Nagpur	(264) The Nagpur Dist. Prajapati (Kumbhar) Co-operative India Society Ltd., Nagpur.	Clay	Q.L.	19·60	23-2-48	10 years
Do.	(265) Shri Ramaraswamy Iyer of Nagpur.	Limestone	Q.L.	10·42	20-2-48	Do.
Do.	(266) Shri M. S. Naiskar of Nagpur	Clay	Q.L.	4·85	17-3-48	Do.
Do.	(267) Shri B.S. Saxena of Kamptee	Clay and Sand	Q.L.	11·5	1-4-48	Do.
Do.	(268) Messrs. New United Construction and Engineering Co., Ltd., Nagpur.	Clay	Q.L.	9·93	5-3-48	Do.

Q.L.=Quarry Lease.
M.L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

CENTRAL PROVINCES AND BERAR—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur . .	(269) Shri Harilal Sheoram of Gondia.	Clay	Q.L.	8·50	2-3-48	5 years
Do. . .	(270) Shri Laxminarayan Hansraj Ghandhi of Nagpur.	Murrum	Q.L.	0·80	7-2-48	10 years
Do. . .	(271) The Manager, R. C. Mission Estate, Nagpur.	Clay	Q.L.	7·78	20-5-48	Do.
Do. . .	(272) Shri K. V. Sane of Dhantoli, Nagpur.	Do.	Q.L.	15·52	26-3-48	Do.
Do. . .	(273) K. S. Chitnavis of Nagpur .	Faranda and Khandki . .	Q.L.	4·30	29-5-48	5 years
Do. . .	(274) Shri M. K. Oke of Dhantoli, Nagpur.	Clay	Q.L.	10·10	8-1-48	10 years
Do. . .	(275) Shri Gajanandashahu of Nagpur.	Do.	Q.L.	2·15	4-4-48	1 year
Do. . .	(276) Shri P. K. Deshraj of Nagpur	Murrum, boulders, rubble and metal.	Q.L.	16·45	29-9-48	5 years

Do. . .	(277) Shri L. H. Ghandhi of Nagpur.	Clay	Q.L.	15·46	5-10-48	10 years
Do. . .	(278) Shri Rajendrapal of Nagpur.	Do.	Q.L.	10·94	23-6-48	Do.
Do. . .	(279) Lonhora Stone Co. of Nagpur.	Do.	Q.L.	8·12	18-10-48	Do.
Do. . .	(280) Shri Guru Bux Singh Attar Singh.	Limestone	Q.L.	13·58	13-10-48	5 years
Do. . .	(281) Shrimati Gopikabai of Nagpur.	Clay	Q.L.	1·96	18-10-48	10 years
Do. . .	(282) Shri Mausoorali Ahsan Hussain Vali.	Do.	Q.L.	3·00	31-5-48	Do.
Do. . .	(283) Shri Shankarsao Sitaramsao Kalar of Kuhi.	Do.	Q.L.	2·73	23-6-48	Do.
Do. . .	(284) Shri M. G. Rawell, Contractor, Nagpur.	Clay and sand . . .	Q.L.	0·70	28-6-48	Do.
Do. . .	(285) Shri Gopal Ramji Parmar of Khapri.	White clay	Q.L.	2·00	Do.	Do.
Do. . .	(286) Shri Yankoo Upashia Yeli of Yerkheda.	Clay	Q.L.	3·00	Do.	..
Do. . .	(287) Shri Kartar Singh Jaswant Singh, Bezonbag, Nagpur.	Limestone	Q.L.	6·47	1-3-48	10 years
Do. . .	(288) Messrs. Sir Sobha Singh and Co., Nagpur.	Clay and sand . . .	Q.L.	6·88	14-6-48	5 years
Do. . .	(289) Shri Pancham Latari .	Clay	Q.L.	2·70	2-8-48	2 years

Q. L.=Quarry Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd

CENTRAL PROVINCES AND BERAR—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur . .	(290) Shri Mahilal Dala Kumbhar of Nagpur.	Clay	Q.L.	1·00	18-8-48	1 year
Do. . .	(291) Shri Bhimsingh Bisen of Manser.	Do.	Q.L.	9·75	21-8-48	10 years
Do. . .	(292) Shri Nathu Bakaram Deshmukh of Kuhi.	Do.	Q.L.	1·10	Do.	2 years
Do. . .	(293) Sk. Sabhan Sk. Ramju Kunjda.	Sand	Q.L.	24·46	24-9-48	5 years
Do. . .	(294) Shri Arjandas Harbanslal of Nagpur.	Clay	Q.L.	12·66	1-10-48	Do
Do. . .	(295) Shri N. L. Naik . .	Do.	Q.L.	2·80	16-11 48	Do.
Do. . .	(296) Shri S. S. Kalar and P. S. Gaikwad of Kuhi.	Do.	Q.L.	9·10	1-4 48	10 years
Do. . .	(297) Shri Vasudeo Nangia of Nagpur.	Clay and Sand . . .	Q.L.	10 00	6-12 48	5 years

Nagpur	(298) Shri F. X. Rebello, Tent Lines, Nagpur.	Clay	Q.L.	2·50	7-10-48	10 years
Do.	(299) Shri Dadasao Paikusao Bhanker of Kuhi.	Do.	Q.L.	5·00	18-11-46	Do.
Do.	(300) Shrimati Chandrabhagabai Kuhi.	Clay and sand	Q.L.	2·28	9-11-46	Do.
Do.	(301) Shri Surya Kanta P. Mehta of Kandri.	Clay	Q.L.	29·97	1-9-47	Do.
Do.	(302) Mst. Rajwantibai	Do.	Q.L.	0·70	24-12-47	5 years
Do.	(303) The trustees of the Estate of of Shri B. R. Goenka.	Manganese-ore	M.L.	118·37	1-9-47	10 years
Do.	(304) Shri K. Mathur and S. S. Kalar of Kuhi.	Clay and sand	Q.L.	8·28	12-2-47	3 years
Do.	(305) Shri D. S. Pophale of Nagpur	Limestone	Q.L.	5·30	23-2-47	5 years
Do.	(306) Shri Deoshya Chandrabhan Kumbhar of Nagpur.	Clay and sand	Q.L.	17·10	8-12-47	10 years
Raipur	(307) Irshad Ali Abdul Hussain, Raipur.	Limestone	Q.L.	4·10	8-10-48	Do.
Do.	(308) Wallarmal, Contractor, Raipur.	Clay	Q.L.	7·80	9-12-48	5 years
Do.	(309) Subedar Singh, Contractor, Raipur.	Sand	Q.L.	4·00	2-3-48	10 years

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

CENTRAL PROVINCES AND BERAR—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Raipur	(310) Narayan Vasta, Contractor, Raipur.	Building Stone	Q.L.	13·53	22-4-48	10 years
Do.	(311) Lekhumal, Contractor, Raipur.	Clay	Q.L.	10·14	4-8-47	5 years
Yeotmal	(312) Shri F. X. Rebello, Nagpur	Limestone	Q.L.	6·00	25-8-47	10 years
Do.	(313) Shri J. D. Costa, Nagpur	Do.	Q.L.	10·29	15-2-47	Do.
Do.	(314) Shri J. M. Dafadey, Hinganghat.	Do.	Q.L.	15·00	5-4-48	Do.
Do.	(315) New Hindusthan Cements Ltd.	Do.	P.L.	261·00	9-10-48	1 year
Do.	(316) Do.	Do.	P.L.	195·16	Do.	Do.

MADRAS

Anantapur . .	(317) Sri S. Ramayya, Tadpatri	Barytes . . .	P. L.	8·85	5-3-48	Do.
Do. . . .	(318) Do. . . .	Do.	P. L.	3·65	4-3-48	Do.
Do. . . .	(319) Sri G. Ramaswami Chetty, Jammalamadugu.	Steatite	P. L.	5·01	Do.	Do.
Do. . . .	(320) Anchil Hussain Perran Sahib of Tadpatri.	Barytes	P. L.	13·97	11-2-48	Do.
Do. . .	(321) S. Ahmed Sheriff Sahib of Cuddappah.	Do.	P. L.	11·85	..	..
Do. . . .	(322) Sri S. Ramayya of Tadpatri.	Do.	P. L.	15·0	22-5-48	1 year
Do. . .	(323) Sri M. C. Ranga Reddi of Pulavendla.	Do.	P. L.	7·85	Do.	Do
Do. . .	(324) Messrs. Kristappa and Sons Cuddapah.	Barytes, Soapstone .	P. L.	16·23	Do.	Do.
Do. . . .	(325) Anchal Hajee Peeran Sahib, Tadpatri.	Barytes . .	P. L.	9·08	4-3-48	Do.

P. L.=Prospecting License.
Q. L.=Quarrry Lease.
M. L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted duringthe year ending 31st December, 1948—contd.

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commence-ment.	Term.
Anantapur .	(326) Sri S. Ramayya, Tadpatri .	Barytes	P. L.	15·60	4-3-48	1 year
Do. . .	(327) Do. . . .	Steatite	P. L.	21·85	22-6-48	Do.
Do. . . .	(328) Sri Longala Narappa . .	Barytes	P. L.	2·65	22-7-48	Do.
Do. .	(329) Do. . . .	Do.	P. L.	19·52	23-8-48	Do.
Do. . . .	(330) Sri Pedda Rangaswami Chetty, Tadpatri.	Do.	P. L .	9·90	17-8-48	Do.
Do. . . .	(331) S. Ahmed Sahib, Cuddapah	Do.	P. L.	106·42	23-9-48	Do.
Do. . . .	(332) Anchal Hajee Peeran Sahib, Tadpatri.	Do.	P. L.	15·85	25-10-48	Do.
Do. . .	(333) Anchal Hajee Peeran Sahib	Do.	P. L.	12·00	Do.	Do.
Do. . . .	(334) Sri P. V. Narayanaswami, Madras.	Steatite	P. L.	8·24	26-10-48	Do.
Do. . . .	(335) Sri G. Ramaswamy Chetty, Jammalamadugu.	Do.	P. L.	50·00	..	Do.
Do. . . .	(336) Anchel Hajee Peeran Sahib, Tadpatri,	Barytes	P. L.	6·20	15-11-48	Do.

Do. . . .	(337) G. Ramaswamy Chetty, Jammalamudugu.	Steatite	P. L.	53·00	19-9-48	Do.
Do. . . .	(338) Sri A. Kullayappa, Puthur .	Barytes	P. L.	6·00	9-9-48	Do.
Do. . . .	(339) Do. . .	China clay	P. L.	7·14	19-9-48	Do.
Do. . . .	(340) Messrs. Andra Chemical Corporation, Viziawada.	Barytes	M. L.	5·25	17-1-48	5 years
Do. . . .	(341) Sri V. Venkatareddi, Venkatampalli.	Yellow Ochre . . .	M. L.	3·89	23-2-48	Do.
Do. . . .	(342) Sri S. Subbaraydu, Tadpatri	Barytes . . .	M. L.	10·58	22-6-48	Do.
Do. . . .	(343) Sri V. Pedda Rangaswamy Chetty, Tadpatri.	Do.	M. L.	21·75	Do.	Do.
Do. . .	(344) Sri Palu Venkatasubbiah, Peddapaya.	Yellow ochre	M. L.	17·67	25-10-48	Do.
Do. . . .	(345) Do. . . .	Barytes	M. L.	25·60	Do.	Do.
Do. . .	(346) Sri M. Narsi Reddy, Pulivendla.	Do.	M. L.	7·75	19-7-48	Do.
Do. . . .	(347) Messrs. Chinnarapa Reddy & Co ..Peddavadupur.	Yellow ochre	M. L.	10·10	18-7-48	Do.
Do. . . .	(348) Sri Palu Venkatasubbiah, Peddapaya.	Barytes	M. L.	76·00	25-10-48	Do.
Do. . . .	(349) Sri G. Ramaswami Chetti, Jammalamadugu.	Steatite	M. L.	41·75	12-8-48	Do.
Do. . .	(350) Sri V. Pappi Reddy, Pulivendla.	Barytes	M. L.	6·00	21-9-48	Do.

P. L.=Prospecting License.
M. L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted duringthe uear ending 31st December, 1948—contd.

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Anantapur	(351) Sri Chinna Seshayya, Kanraampalli, Velisivarpalli.	Barytes	M. L.	9·95	21-9-48	5 years
Do.	(352) Sri Sudharamayya, Tadpatri	Do.	M. L.	20·70	29-10-48	Do.
Do.	(353) Messrs. D. Venkata Ramana Rao and Sons, Jammalamudugu.	Do.	M. L.	3·75	24-11-48	Do.
Do.	(354) Sri G. Ramaswami Chetty, Jammalamadugu.	Do.	M. L.	9·10	16-7-48	Do.
Do.	(355) Messrs. Parry & Co., Madras	Kaolin and Felspar	M. L.	2·34	10-12-48	Do.
Do.	(356) Sri Palu Venkatasubbiah, Pedaya.	Asbestos	M. L.	32·00	..	*5 years
Do.	(357) Sri Palu Venkatasubbiah, Peddapaya.	Barytes	M. L.	93·75	9-11-48	Do.
Bellary	(358) Sri A. P. Ramaiah, Bellary	Oxide of iron, Iron ores, Red earth, Ochres.	P. L.	640	15-5-48	1 year
Do.	(359) Sri G. Chennappa	Manganese ore	M. L.	259·37	30-10-48	5 years
Do.	(360) Sri A. P. Ramaiah, Bellary	Red earth ore, Oxide of iron	M. L.	130	4-7-48	10 years

Cuddapah . . .	(361) Messrs. Punt and Rao, Madras.	Barytes	M. L.	17·55	11-2-48	5 years
Do. . . .	(362) Sri Molla Reddi of Kondapuram.	Barytes & Asbestos . .	M. L.	74·51	20-4-48	Do.
Do. . . .	(363) Messrs. Parry & Co. Ltd., Madras.	China clay	M. L.	7·48	11-6-48	Do.
Do. . . .	(364) Nane Sahb, Muddanur	Barytes	M. L.	23·00	8-7-48	Do.
Do. . . .	(365) Do.	Do.	M. L.	10·00	Do.	Do.
Do. . . .	(366) Abdul Hakim of Cuddapah	Yellow ochre . . .	M. L.	10·40	17-7-48	Do.
Do. . . .	(367) Do.	Do.	M. L.	0·94	2-9-48	Do.
Do. . . .	(368) Sri Ramachand Reddy of Cuddapah.	Barytes	M. L.	4·97	16-8-48	Do.
Do. . . .	(369) Syed Abdul Khader Sahib	Do	M. L.	10·62	17-10-48	Do.
Do. . . .	(370) Sri M. Rama Rao of Cuddapah.	Do.	M. L.	0·54	31-10-48	Do.
Do. . . .	(371) Sri Venkata Reddi of Venkatampalli.	Do.	M. L.	3·50	15-11-48	Do.
Do. . . .	(372) Messrs. Parry & Co., Ltd. .	China clay	M. L.	10·00	17-11-48	15 years
Do. . . .	(373) Sri S. V. Venkata Reddi .	Barytes	P. L.	5·07	12-12-48	1 year
Do. . . .	(374) Abdul Khader Sahib of Cuddapah.	Do.	P. L.	5·00	13-1-48	Do.
Do. . . .	(375)) Sri Ram Chandra Reddy .	Do.	P. L.	16·76	17-1-48	Do.
Do. . . .	(376) Sri Balaiah	Do.	P. L.	9·23	9-2-48	Do.
Do. . . .	(377) Renga Reddi of Pulivendla	Do.	P. L.	3·80	11-2-48	Do.
Do. . . .	(378) Abdul Khader Sahib of Cuddapah.	Yellow ochre	P. L.	9·50	13-2-48	Do.

*Pending registration.
P. L.=Prospecting License.
M. L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED —*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Cuddapah . .	(379) Abdul Hakim Sahib of Cuddapah.	Barytes	P. L.	..	18-2-48	1 year
Do. . . .	(380) Mahboob Miah . .	Do.	P. L.	1·55	6-3-48	Do.
Do. . . .	(381) Sri V. V. Subbaiah Pantulu of Pulivendla.	Do.	P. L.	6·05	10-3-48	Do.
Do. . . .	(382) Abdul Khader . . .	Do.	P. L.	21·00	24-3-48	Do.
Do. . . .	(383) Sri V. V. Subbiah Pantulu of Pulivendla.	Do.	P. L.	3·60	7-4-48	Do.
Do. . . .	(384) Do.	Do.	P. L.	30·75	Do.	Do.
Do. . . .	(385) Sri Baliah Chetti of Cuddapah.	Do.	P. L.	32·74	10-4-48	Do.
Do. . . .	(386) U. Venkatareddi of Pulivendla.	Do.	P. L.	13·40	Do.	Do.
Do. . . .	(387) Abdul Khader of Cuddapah	Do.	P. L.	10·00	30-4-48	Do.
Do. . . .	(388) Sri Venkata Pulivendla .	Do.	P. L.	9·44	Do.	Do.
Do. . . .	(389) Bagadi Chetty of Pulivendla	Do.	P. L.	3·74	13-5-48	Do.

Do.	(390) Abdul Khader of Cuddapah	Do.	P. L.	2·40	14-5-48	Do.
Do.	(391) Messrs. Tiffin & Co., Cuddapah.	Do.	P. L.	8·73	27-5-48	Do.
Do.	(392) Abdul Khader of Cuddapah	Do.	P. L.	5·00	Do.	Do.
Do.	(393) Sri Venkataramana Rao of Jammalamadugu.	Do.	P. L.	126·0	1-6-48	Do.
Do.	(394) K. Ayyanna Chetty of Cuddapah	Do.	P. L.	7·75	13-6-48	Do.
Do.	(395) Do.	Do.	P. L.	8·82	Do.	Do.
Do.	(396) Do.	Do.	P. L.	11·10	15-5-48	Do.
Do.	(397) Bagadichetti of Pulivendla	Barytes	P. L.	5·64	8-7 48	Do.
Do.	(398) Qabula Reddy	Do.	P. L.	4·01	Do.	Do.
Do.	(399) Messrs. Tiffin & Co., Cuddapah.	Asbestos	P. L.	25·58	6-8 48	Do.
Do.	(400) G. Nanasahib of Mudanur	Barytes	P. L.	4·02	15-7-48	Do.
Do.	(401) Sri K. Ayyanna Chetty of Cuddapah.	Do.	P. L.	35·30	Do.	Do.
Do.	(402) Messrs. General Trading Co. of Cuddapah.	Do.	P. L.	21·53	24-9-48	Do.
Do.	(403) Sri Beliah Chetty of Cuddapah.	Do.	P. L.	15·43	17-10-48	Do.
Do.	(404) Sri P. Venkatasubba Reddi of Pulivendla.	Do.	P. L.	5·87	31-10-48	Do.
Do.	(405) Sri Mitta Baliah Chetty of Cuddapah.	Do.	P. L.	5·60	Do.	Do.
Do.	(406) Sri P. Venkatasubba Reddy of Peddakudala.	Do.	P. L.	17·55	Do.	Do.

P. L.=Prospecting License.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Cuddapah . .	(407) Abdul Hakim of Cuddapah	Barytes . . .	P. L.	5·60	10-11-48	1 year
Do. . . .	(408) Sri Mitta Baliah Chetty of Cuddapah.	Do.	P. L.	7·10	11-11-48	Do.
Do. . . .	(409) Do. . .	Do.	P. L.	16·81	21-11-48	Do.
Do. . . .	(410) Abdul Hakim of Cuddapah	Do.	P. L.	33·50	11-11-48	Do.
Do. . . .	(411) Syed Abdul Khader . .	Do.	P. L.	10·50	21-11-48	Do.
Do. . . .	(412) Messrs. General Trading Co. of Cuddapah.	Do.	P. L.	11·25	2-12-48	Do.
Do. . . .	(413) Abdul Hakim	Do.	P. L.	5·02	Do.	Do.
Do. . . .	(414) Abdul Khader	Do.	P.L.	5·17	27-11-48	Do.
Do. . . .	(415) Sri C. Anjaneyalu Chetty of Tadpatri.	Do.	P. L.	3·55	30-12-48	Do.
Do. . .	(416) Sri Mitta Balia Chetty of Cuddapah.	Do. . . .	P. L.	71·77	21-12-48	Do.
Do. . . .	(417) Abdul Hakim of Cuddapah	Do.	P. L.	50·88	6-12-48	Do.

Guntur . . .	(418) B. Maridoss . . .	Slabs	M. L.	(a)	(a)	5 years
Do. . . .	(419) Sri D. Venkatadri Naidu .	Red ochre	M. L.	(a)	(a)	Do.
Kurnool . .	(420) Sri K. Narayana . .	Barytes	M. L.	28·00	24-3-48	Do.
Do. . . .	(421) Do. . . .	Do.	M. L.	18·25	10-2-48	Do.
Do. . . .	(422) Sri B. T. Nagiradali . .	Do.	M. L.	8·60	23-3-48	Do.
Do. . . .	(423) Do. . . .	Do.	M. L.	27·80	Do.	Do.
Do. . . .	(424) Sri K. Narayaniah . .	Barytes and Red oxide of iron.	M. L.	50·00	14-5-48	Do.
Do. . . .	(425) Do. . . .	Barytes	M. L.	38·90	20-5-48	Do.
Do. . . .	(426) Sri K. Ramasubba Rao .	Yellow ochre & White shale .	M. L.	2·50	16-5-48	Do.
Do. . . .	(427) Sri K. Venkataswamy .	Do.	M. L.	3·84	21-5-48	Do.
Do. . . .	(428) Sri K. Ramasubba Rao .	Do.	M. L.	20·80	16-5-48	Do.
Do. . . .	(429) Sri B. V. Joshi . .	Slatestone	M. L.	88·35	19-5-48	Do.
Do. . . .	(430) Sri U. B. Buggaiah . .	Yellow ochre & White shale	M. L.	21·54	14-5-48	Do.
Do. . . .	(431) Sri Rao Bahadur M. Veeraswamy.	Barytes	M. L.	52·37	21-5-48	Do.
Do. . . .	(432) Sri Y. Yellareddy . .	Do.	M. L.	95·0	20-5-48	Do.
Do. . . .	(433) Sri D. Hanumantha Reddy	Do.	M. L.	20·00	21-5-48	Do.
Do. . . .	(434) Sri M. C. Narasi Reddy .	Slatestone	M. L.	20·02	30-6-48	Do.

(a) Not known.
M. L.=Mining Lease.
P. L.=Prospecting License.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December. 1948—contd.

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kurnool . .	(435) Sri M. Narsi Reddy . .	Yellow ochre & White shale .	M. L.	20·00	11-7-48	5 years
Do. . . .	(436) Sri T. K. Rami Reddy .	Yellow ochre	M. L.	3·40	15-8-48	Do.
Do. . . .	(437) Sri R. V. Ramiah Chetty	Barytes	M. L.	16·19	6-8-48	Do.
Do. . . .	(438) Sri D. Hanumantha Reddy	Do.	M. L.	20·65	31-7-48	Do.
Do. . . .	(439) Sri T. R. Rami Reddy .	Yellow ochre	M. L.	3·40	15-8-48	Do.
Do. . . .	(440) Sri B. T. Nagi Reddy .	Barytes	M. L.	35·40	23-9-48	Do.
Do. . . .	(441) Do. . . .	Do.	M. L.	16·00	22-9-48	Do.
Do. . . .	(442) Do. . . .	Barytes & Red oxide of iron	M. L.	2·91	15-8-48	Do.
Do. . . .	(443) K. Thippa Reddy . .	Yellow ochre	M. L.	4·80	1-9-48	Do.
Do. . . .	(444) D. R. G. Ranakola Rayadu	Yellow ochre & White shale .	M. L.	14·70	23-9-48	Do.
Do. . . .	(445) Sri Subbarayudu Chetty .	Barytes	M. L.	24·06	6-8-48	Do.
Do. . . .	(446) Do. . . .	Do.	M. L.	9·00	Do.	Do.
Do . . .	(447) Sri K. B. Basiah .	Do.	M. L.	42·68	30-6-48	Do.

Do.	(448) Sri D. Venkata Rama Rao, Jammalmadugu.	Do.	P. L.	37·40	13-5-48	1 year
Do.	(449) Sri D. Hanumantha Reddy, Bellary.	Steatite	P. L.	12·00	27-1-48	Do.
Do.	(450) Do.	Do.	P. L.	8·00	27-1-47	Do.
Do.	(451) Sri S. Narayana Reddy, Bethamoherla.	Barytes	P. L.	20·00	4-6-48	Do.
Do.	(452) Do.	Do.	P. L.	20·00	Do.	Do.
Do.	(453) Sri S. Narayana Reddy, Bethamoherle.	Do.	P. L.	25·12	5-6-48	Do.
Do.	(454) Sri O. N. Jogi of Kurnool	Do.	P. L.	6·90	29-7-48	Do.
Do.	(455) Sri B. Sanjeeva Reddy, Bethamcherla.	Do.	P. L.	10·50	1-8-48	Do.
Do.	(456) Sri S. Narayana Reddy	Do.	P. L.	9·10	7-8-48	Do.
Do.	(457) Do.	Do.	P. L.	60·0	Do.	Do.
Do.	(458) Do.	Do.	P. L.	16·90	Do.	Do.
Do.	(459) Sri B. R. Bugga Reddy, Bethamcherla.	Do.	P. L.	8·00	8-9-48	Do.
Do.	(460) Do.	Do.	P. L.	16·00	Do.	Do.
Do.	(461) Do.	Do.	P. L.	4·10	15-9-48	Do.
Do.	(462) Do.	Do.	P. L.	9·40	16-9-48	Do.
Nellore	(463) Pellakur Rama Chandra Reddy	Mica	P. L.	3·0	31-7-48	Do.

P. L.=Prospecting License.
M. L.=Mining Lease,

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

MADRAS—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore . .	(464) Ramannapolusn of Kuvur	Mica	P. L.	25·10	15-5-48	1 year
Do. . . .	(465) Kuram Kota Reddy .	Do.	P. L.	24·76	24-5-48	Do.
Do. . . .	(466) Rokala Balakrishnayya, Gudur.	Do.	P. L.	29·55	22-7-48	Do.
Do. . . .	(467) Bari Venkalal Ramakrishnaiah, Stone Housepet, Nellore.	Do.	P. L.	3·54	16-7-48	Do.
Do. . . .	(468) Vennireddy Sivakota Reddy, Gudur.	Do.	P. L.	38·73	29-7-48	Do.
Do. . . .	(469) Sarangam Bela Krishniah Kota, Gudur.	Do.	P. L.	13·70	1-9-48	Do.
Do. . . .	(470) D. Narasimha Rao, Globe Mica" Co., Gudur.	Do.	P. L.	9·38	27-8-48	Do.
Do. . . .	(471) Bozwada Sivakota Reddy Beetchi Reddy, Palem.	Do.	P. L.	28·75	16-9-48	Do.
Do. . . .	(472) Siddareddy Venkureddy Brindavananm, Nellore.	Do. . . .	M. L.	3·06	23-1-48	20 years
Do. . . .	(473) Kolli Dasaratharami Reddy, Kovur.	Do. . . .	M. L.	4·38	14-1-48	Do.

Do. . . .	(474) M. Venkatachalam Naidu.	Do. . .	M. L.	39·52	14-3-48	Do.
Do. . . .	(475) Rao Sahib Jakkapattabi Rama Reddy of Kallayaka Gollod and Kondera Venkata Ramana Reddy, North Mopur.	Do. . . .	M. L.	31·86	15-5-48	Do.
Do. . . .	(476) Berimukala Ramkrishnaiah, Stone Housepet, Nellore.	Do.	M. L.	7·85	18-4-48	Do.
Do. . . .	(477) Bommu Subbiah Chetty, Gudur.	Do.	M. L.	9·86	29-6-48	Do.
Do. . .	(478) Sri Abbiraju Venkata Subbiah.	Do.	P. L.	68·60	13-9-47	1 year
Do. . . .	(479) Bramanaedam Vonkatoswarlu, Repapula Street, Stone Housepet, Nellore.	Do.	M. L.	39·50	27-8-47	20 years
Nilgiris . . .	(480) M. K. Powell, Mining Engineer, Mango Range.	Do.	P. L.	15·76	15-4-48	1 year
South Arcot . .	(481) Messrs. Parry & Co., Madras.	White clay	M. L.	6·72	18-2-48	20 years
Do. . .	(482) Do. .	China clay	M. L.	8·65	Do.	Do.
Trichinopoly . .	(483) Trichinopoly Mining Works, Trichinopoly.	Calestite	M. L.	77·43	1-1-48	7 years
Tinnevelly . .	(484) Ponnusamy Nadar Marakatti Villai Karaichetty Pudur of Nanguneri.	Garnet sand	M. L.	0·32	9-9-48	5 years

ORRISA

Mayurbhanj State	(485) Sri H. N. Thakur . .	Soapstone and mica . .	M. L.	220·73	19-4-48	10 years

M. L.=Prospecting License.
P. L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

UNITED PROVINCES

District.	Grantee.	Mineral.	Nature of grant.	Area in acres	Date of commencement	Term.
Garhwal . .	(486) Shri Brij Lal Suri, Northern India Lime Marketing Association, Rest Camp, Dehra Dun.	Sulphates, carbonates phosphates and silicates.	P. L.	1,300	22-6-48	1 year

HYDERABAD

District.	Grantee.	Mineral.	Nature of grant.	Area in acres	Date of commencement	Term.
Adilabad . .	(487) The Deccan Porcelain and Potteries Ltd.	White clay	Q. L.	10	3-9-48	3 years
Do. . .	(488) Mr. Karsandas L. Rathod	Do.	Q. L.	8	12-4-48	Do.
Do. . .	(489) Mr. Narsi Pancha . .	Do.	Q. L.	12·5	13-4-48	Do.
Do. . .	(490) Messrs. Khan Bahadur Ahmed Alladin & Co.	Do.	Q. L.	100	18-5-48	1 year
Do. . .	(491) The Hyderabad Potteries Ltd.	Do.	Q. L.	20	31-12-48	5 years
Aurangabad . .	(492) Mr. Pannalal . . .	Buildingstone . . .	Q. L.	(*a*)	1-10-48	1 year

Do.	(493). Do.	Do.	Q. L.	(*a*)	Do.	Do.
Do.	(494). Mr. Motilal	Do.	Q. L.	(*a*)	Do.	Do
Do.	(495). Mr. Mohd. Ibrahim	Do.	Q. L.	(*a*)	Do.	Do.
Do.	(496). Mr. Jamla Naik	Do.	Q. L.	(*a*)	Do.	Do.
Bidar	(497). Mr. Abdul Aziz Sikandar	Red ochre	Q. L.	(*a*)	14-4-48	3 years.
Gulbarga	(498). Messrs. Rahmatulla Veerji & Bros.	Limestone	Q. L.	86	Do.	5 years.
Do.	(499). Md. Moulana Sahib	Do.	Q. L.	(*a*)	25-11-48	Do.
Do.	(500). The Deccan Porcelain and Potteries Ltd.	Feldspar	P. L.	20	16-9-48	1 year.
Karimnagar	(501). Mr. Abdulla Khan	Limestone	Q. L.	(*a*)	22-5-48	1½ years.
Do.	(502). The Sirpur Paper Mills Ltd	Steatite	Q. L.	2·5	22-9-48	1 year.
Do.	(503). Do.	Do.	Q. L.	1·5	5-2-48	Do.
Mahbub Nagar	(504). Mr. Syed Ahmed	Mill stones	Q. L.	(*a*)	30-6-48	Do.
Raichur	(505). Mr. Bashiruddin Khan	Limestone	Q. L.	(*a*)	15 2-48	Do.
Warangal	(506). The Singareni Colls. Co.	Coal	P. L.	1,731	13-1-48	Do.
Do.	(507). Mr. Chenna Keshavulu	Garnets	P. L.	2,240	5-4-48	Do.
Do.	(508). Mr. Mohd. Kasim	Building stone	Q. L.	(*a*)	1-10-48	Do.

P. L.=Prospecting License.
M. L.=Mining Lease.
(a) Not Known

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions terminated the year ending 31st December, 1948—contd.

MADHYA BHARAT.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Barwani State	(509). Messrs. Manganese Mining Corporation, Indore.	Manganese Ore	P. L.	640	13-6-48	1 year.
Jobat	(510). R. N. Amin, Bombay	White clay	M. L.	(*a*)	1-4-48	10 years.
Do.	(511). Do.	Black clay	M. L.	(*a*)	Do.	Do.

MYSORE.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bangalore	(512). Mysore Stoneware Pipes and Potteries, Ltd.	Kaolin, Quartz and Feldspar	P. L.	325	20-3-48	1 year.
Do.	(513). Do.	Kaolin	P. L.	980	22-7-48	Do.
Do.	(514.) The Standard Brick and Tile Co., Ltd., Yelahanka.	Do	M. L.	80	(*a*)	10 years.
Do.	(515). The Mysore Glass and Enamel Works.	Quartz	M. L.	80	3-8-47	Do.
Hassan	(516). P. S. Narayana	Corundum	P. L.	1,280	22-9-47	1 year.

Do. . . .	(517). Do.	Soapstone, Corundum, Kyanite, Staurolite, Graphite and Asbestos.	P. L.	1,920	6-5-48	Do.
Do. . . .	(518). Do.	Staurolite	P. L.	2,560	20-10-47	Do.
Do. . . .	(519). M. Narasi Reddy . .	Kyanite	P. L.	640	15-11-48	Do.
Do. . . .	(520). P. N. Anjaira . . .	Mica	P. L.	960	16-9-48	Do.
Kolar . . .	(521). B. K. Narayan Singh .	Ochres	P. L.	1,280	17-6-48	Do.
Do. . . .	(522). Do. . . .	Mica, Garnet and Corundum .	P. L.	2,560	1-8-48	Do.
Do. . . .	(523). Abdul Sattar . .	Kaolin	P. L.	320	28-7-48	Do.
Do. . . .	(524). S. Rama Iyer . . .	Ochres	P. L.	640	28-10-48	Do.
Do. . . .	(525). B. K. Narayan Singh .	Chrome and Magnesite . .	P. L.	640	9-6-48	Do.
Do. . . .	(526). Do. . . .	Corundum	P. L.	640	16-4-48	Do.
Do. . . .	(527). Do. . . .	Agate	P. L.	320	30-11-47	Do.
Do. . . .	(528). Do. . . .	Corundum and Garnet . .	P. L.	1,280	11-6-48	Do.
Do. . . .	(529). C. A. Abdul Rahim . .	Kaolin	P. L.	320	30-11-47	Do.
Do. . . .	(530). A. V. Krishnamurthy Rao	Do.	P. L.	320	27-11-47	Do.
Mandya. . .	(531). N. N. Anjaria . . .	Asbestos	P. L.	320	13-7-48	Do.

P. L.=Prospecting License.
M. L.=Mining Lease.
(*a*) Not known.

DETAILS OF MINERAL CONCESSIONS GRANTED—*contd.*

Statement of Mineral Concessions granted during the year ending 31st December, 1948—contd.

MYSORE—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mysore.	(532). V. Sundaramurtyh	Chrome	P. L.	640	22-6-48	1 year.
Do.	(533). Do.	Do.	P. L.	640	Do.	Do.
Do.	(534). P. N. Anjaria	Chrome and Magnesite	P. L.	320	4-2-48	Do.
Do.	(535). M. Viraraj Ura	Do.	P. L.	640	16-1-48	Do.
Do.	(536). Do.	Corundum	P. L.	640	Do.	Do.
Do.	(537). B. K. Narayana Singh	Ruby Corundum	P. L.	320	27-7-48	Do.
Do.	(538). Do.	Mica and Garnet	P. L.	640	30-12-48	Do.
Do.	(539). H. Subramanya Iyer	Asbestos	P. L.	320	9-9-48	Do.
Do.	(540). B. K. Narayan Singh	Mica	P. L.	1,920	25-10-48	Do.
Do.	(541). Mysore Chromite Ltd.	Chrome	M. L.	137	6-10-47	10 years.
Do.	(542). R. B. Gowda	Asbestos	P. L.	640	5-2-48	1 year.
Do.	(543). P. N. Anjaria	Chrome	P. L.	640	22-7-48	Do.

Do.	(544). V. T. Venugopal	Dolomite Limestone	P. L.	320	11-12-48	Do.
Do.	(545). P. N. Anjaria	Asbestos	P. L.	320	4-10-48	Do.
Do.	(546). Hyder Ali Khan	Chromite	P. L.	320	5-5-48	Do.
Tumkur	(547). P. N. Anjaria	Quartz, Quartzite and Manganese Ore dioxide.	P. L.	320	25-5-48	Do.
Do.	(548). B. K. Narayan Singh	Rock Crystals	P. L.	1,280	27-7-48	Do.
Do.	(549). Mysore Stoneware Pipes and Potteries, Ltd.	Kaolin	P. L.	1,280	24-7-48	Do.
Do.	(550). B. K. Narayan Singh	Ochre	P. L.	1,280	23-12-48	Do.
Do.	(551). G. Chennabasappa	Soapstone	P. L.	(a)	30-10-47	Do.
Do.	(552). T. L. Narasinghbhan	Do.	P. L.	(a)	15-12-47	Do.

PATIALA AND EAST PUNJAB STATES UNION.

Mashuta	(553). Messrs. Rajputana Minerals Ltd., 10, Alipur Road, Civil Lines, Delhi.	Barytes	M. L.	..	1-1-48	10 years.
Surajpur	(554). Messrs. Patiala Cement Co., Ltd., Surajpur.	Limestone, Shales and Gypsum	M. L.	42·55	22-2-46	22 years

(a) Not known.
P. L.=Prospecting License.
M. L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS GRANTED—*concld.*

Statement of Mineral Concessions terminated during the year ending 31st December, 1948—concld

RAJASTHAN

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Alwar	(555). L. Chandgilal Vaish, Alwar	Soapstone, Calcite	P. L.	160	21-3-48	1 year.
Do.	(556). Do.	Do.	P. L.	160	Do.	Do.
Dungarpur	(557). Shri Laxmi Minerals, Sagwara, Dungarpur.	Precious and semi-precious stones	M. L.	Whole of Dungarpur Dt.	1-1-48	15 years.
Do.	(558). Tilock Chand Newar	Mica	Do.	640	Do.	1 year.
Do.	(559). Daudayal Mohta	Do.	Do.	640	1-2-48	Do.
Do.	(560). Ram Narayan Tank	Do.	Do.	640	Do.	Do.
Do.	(561). Damodar Dass Khandelwal	Do.	Do.	640	Do	Do.
Do.	(562). Sitaram Sodhani	Do.	Do.	(a)	1-3-48	Do.
Do.	(563). Ram Narayan Tank	Do.	Do.	(a)	Do.	Do.
Do.	(564). Do.	Do.	Do.	(a)	1-4-48	Do.
Do.	(565). Bhanwari Sahai	Do.	Do.	(a)	Do.	Do.
Do.	(566). Do.	Do.	Do.	(a)	Do.	Do.
Do.	(567). Do.	Do.	Do.	(a)	1-5-48	Do.
Do.	(568). Ramswaroop	Do.	Do.	(a)	1-4-48	Do.
Do.	(569). Sree Gopal Bihani	Do.	Do.	(a)	1-6-48	Do.
Do.	(570). K. S. Bhandari	Emerald	P. L.	(a)	1-2-48	Do.
Do.	(571). Do.	Do.	Do.	(a)	Do.	Do.
Karauli	(572). Krishna Mining Syndicate, Naraul, Karauli.	Red Ochre	M. L.	(a)	1-3-48	10 years.
Do.	(573). Do.	Silica	M. L.	(a)	Do.	7 years.
Do.	(574). Nathoolal Bohara, Karauli	Yellow Ochre	M. L.	(a)	1-7-47	3 years.
Do.	(575). Bhoorolal, Karauli	Do.	M. L.	(a)	Do.	Do.

Udaipur	(576). R. B. Seth Moolchand Suganchand, Udaipur.	Emerald	P. L.	3,200	16-3-48	1 year.
Do.	(577). Seth Pusalal Mansinghka, Bhilwara.	Do.	P. L.	3,200	25-1-47	Do.
Do.	(578). R.B. Buldeodas Rameshwarji Nathany, Calcutta.	Do.	P. L.	3,200	28-3-48	Do.
Do.	(579). The Mewar Mineral Co.	Mica	P. L.	896,000	20-1-48	1 year and 9 months.
Do.	(580). The Mewar Industrial and Commercial Syndicate Ltd., Udaipur.	Soapstone, Talc, Steatite	P. L.	10 miles radius around Eklingji temple.	26-10-48	1 year.
Sirohi State	(581). Messrs. Hazari Lal & Co., Udaipur.	Mica	P. L.	1,276,160	27-10-46	2 years.
Do.	(582). Messrs. Jeewan and Sons, Abu road.	China clay	P. L.	384,000	1-5-48	Do.
Do.	(583). Do.	Soapstone	P. L.	384,000	Do.	Do.

VINDHYA PRADESH

Kothi State	(584). Ramadhar Agarwal, Kothi.	Ochre	M. L.	15	21-2-48	4 years.
Rewa State	(585). Shri J. K. Saraf, Bombay	Coal	M. L.	1,196·80	27-11-48	30 years.
Do.	(586). Amar Singh, Hardwarilal	Do.	M. L.	1,098·67	31-3-48	Do.
Do.	(587). Diwan Lime Co., Maihar	Limestone	M. L.	414·26	..	20 years.
Do.	(588). Munnalal Pasari & Sons, Satna.	Corundum	M. L.	2354	..	6 years.
Sohawal State	(589). Shankar Pad Murarka, Jaitwara.	Ochre	P. L.	25	20-4-48	1 year.
Do.	(590). Mahadeo Pad Jaitwara	Do.	P. L.	14	21-6-48	Do.
Do.	(591). Messrs. Indian Minerals Ltd	Do.	P. L.	55	17-2-48	Do.
Do.	(592). Sheoratanlal Jaitwara.	Do.	P. L.	25	22-1-47	Do.
Do.	(593). Bholanath Murarka, Jaithwara	Do.	P. L.	10	23-1-47	Do.
Do.	(594). Do.	Do.	P. L.	10	9-1-47	Do.

P. L.=Prospecting License.
M. L.=Mining Lease.
(a) Not available.

DETAILS OF MINERAL CONCESSIONS TERMINATED.

Statement of Mineral Concessions terminated during the year ending 31st December, 1948.

AJMER-MERWARA

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of Termination.
Ajmer	1. Messrs. Jivraj Bhanji and Co., Ajmer.	Mica, Felspar, Quartz, Beryl	P. L.	1·36	22-2-47	21-2-48
Do.	2. R. B. Seth, Sir, Bhag Chand Soni, Ajmer.	Mica, Beryl	P. L.	2·38	17-3-47	16-3-48
Do.	3. L. Kalyanmal Tak, Ramsar.	Soapstone, Quartz, Mica	P. L.	8·42	7-8-47	6-2-48
Do.	4. R. B. Seth, Sir Bhag Chand Soni, Ajmer.	Mica, Kyanite, Beryl, Soapstone, Emerald, Ruby and Sapphire.	P. L.	42·73	27-8-47	26-8-48
Do.	5. Do.	Mica, Asbestos, Soapstone	P. L.	10·78	17-7-47	16-7-48
Do.	6. Do.	Beryl, Ruby, Kyanite, Emerald. Sapphire, Aquamarine.	P. L.	9·71	3-9-47	2-9-48
Do.	7. Sri Bhag Chand Soni, Ajmer	Mica, Kyanite, Soapstone, Asbestos, Quartz, Beryl, Ruby, Sapphire, Emerald and Aquamarine.	P. L.	14·58	Do.	Do.
Do.	8. Shri Panchulal Sethi, Sanod	Mica	P. L.	1·2	7-10-47	6-10-48

Do.	9. Sir Bhag Chand Soni, Ajmer	Mica, Quartz, Asbestos, Soapstone, Beryl, Ruby, Sapphire, Emerald and Aquamarine.	P. L.	23·84	17-7-47	16-7-48
Beawar	10. Shri Ramballabh Agarwal, Mica Mine Owner, Ajmer.	Mica	P. L.	6·37	3-7-47	2-7-48
Do.	11. M. Akbar Ali Rajab Ali, Beawar.	Mica and Beryl	P. L.	1·24	4 2-47	3-2-48
Do.	12. Rajasthan Mines Ltd., Beawar	Mica, Beryl, Felspar	M. L.	·18	18-5-45	1948
Do.	13. Mr. Sahibchand Surana, Beawar.	Mica, Felspar	P. L.	5·68	10-3-47	9-3-48
Do.	14. Do.	Do.	P. L.	·97	Do.	Do.
Do.	15. Mr. Shamlal Pragnarain, Ajmer.	Mica, Felspar, Quartz, Beryl	P. L.	8·74	30-5-47	29-5-48
Do.	16. Mr. J. K. Soneji, Ajmer	Do.	P. L.	3·26	22-3-47	21-3-48
Do.	17. Messrs. Bhattacharya & Sons, Ajmer.	Mica and Beryl	P. L.	8·14	10-3-47	9-3-48
Do.	18. Do.	Mica, Quartz, Felspar, Asbestos, Soapstone, Beryl.	P. L.	1·72	8-5-47	7-5-48
Do.	19. *Shiv Ratan G. Mohatta*	Mica	P. L.	6·84	15-3-47	14-3-48
Kekri	20. Messrs. Chouthmal Bhanwarlal Kabra, Kekri.	Do.	M. L.	(*a*)	10-2-47	1948

P. L.=Prospecting License.
M. L.=Mining Lease.
(*a*) Not available.

DETAILS OF MINERAL CONCESSIONS TERMINATED—*contd.*

Statement of Mineral Concessions terminated during the year ending 31st December, 1948—contd.

BIHAR

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of Termination.
Santhal Parganas .	21. Nangi Manji . . .	Stone	Q. L.	23·32	1-4-45	31-3-48
Do. . .	22. K. L. Bhagat . . .	Do.	Q. L.	5·00	1-2-45	31-1-48
Do. . .	23. Mr. A. S. Appear . .	Do.	Q. L.	11·35	1-11-45	31-10-48
Do. . .	24. B. N. Sett and Brothers .	Do.	Q. L.	35·53	1-4-45	1-3-48
Singhbhum . .	25. Babu Harendra Nath Hui Mazumder.	Slate stone	Q. L.	60·80	12-6-43	11-6-48
Do. . .	26. S. P. Bey and B. B. Prasad .	Limestone	Q. L.	7·00	1-4-38	31-3-48
Do. . .	27. Babu Narshi Harjee . .	Ballast	Q. L.	80	23-7-43	22-7-48
Do. . .	28. Babu M. L. Rungta . .	Quartzite	Q. L.	40	7-12-43	6-12-48

Ratnagiri . .	33. Messrs. Balkrishna Das & Co., Kharghat, Bombay.	Mica	P. L.	9·12	30-11-46	29-11-48
Satara South . .	34. Gafar Babaji, Bhokare .	Black stone and Metal . .	Q. L.	·12	1-6-45	31-5-48
Do. . .	35. Bala Laxman Kalkatti .	Do. . . .	Q. L.	·12	Do.	Do.
Do. . .	36. Babu Narayan Panhalkar .	Do. . . .	Q. L.	·12	Do.	Do.
Do. . .	37. Nagu Sarala Wadar . .	Do. . . .	Q. L.	·12	14-9-45	Do.
Do. . .	38. Maruti Ganpat Kokate & Co.	Do. . . .	Q. L.	·12	1-6-47	Do.
Do. . .	39. Babu Sheti Vadar Sangli .	Do. . . .	Q. L.	·12	Do.	Do.
Shahabad . .	29. Messrs. Kutehwar Lime and Stone Co., Ltd.	Limestone	M. L.	137	1-4-28	31-3-48
Do. . .	30. Do. . . .	Do.	M. L.	82·76	Do.	Do.
Do. . .	31. Messrs. Sone Valley Portland Cement Co., Ltd.	Chromite	M. L.	77·54	1-1-19	31-12-48
Singhbhum . .	32. Sir Indra Singh . . .	Do.	M. L.	500	27-1-28	26-1-48

Q. L.=Quarry Lease.
M. L.=Mining Lease.

DETAILS OF MINERAL CONCESSIONS TERMINATED—*contd.*

Statement of Mineral Concessions terminated during the year ending 31st December, 1948—contd.

CENTRAL PROVINCES AND BERAR

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of Termination.
Bilaspur . .	40. Shri Mulji Jagmal . .	Limestone	Q. L.	3·43	11-4-43	13-5-48
Chanda . .	41. Mohammad Hussain R. Hashamabhoy, General Merchant, Chanda.	Yellow Ochre . . .	Q. L.	11·25	17-6-38	16-6-48
Do. . . .	42. The Hon'ble Sir Maneckji, B. Dadabhoy.	Sand	Q. L.	104·98	29-6-38	28-6-48
Chhindwara . .	43. Shri M. A. Razzaque, Chhindwara.	Coal	P. L.	142·86	3-3-47	2-3-48
Do. . . .	44. Do. . . .	Do.	P. L.	140·11	Do.	Do.
Do. . . .	45. The Central Potteries Ltd., Nagpur.	Felspar	P. L.	3·28	20-3-47	19-3-48
Do. . . .	46. Do. . . .	Do.	P. L.	16·25	Do.	Do.
Do. . . .	47. Shri N. H. Ojha & Co., Ltd., Calcutta.	Coal	P. L.	143·00	1-5-47	30-4-48
Do. . . .	48. Shri Mavji Raja, Chhindwara	Limestone	Q. L.	3·58	12-10-46	3-2-48
Do. . . .	49. Shri K. S. M. Hassonji & Sons, Nagpur.	Coal	M. L.	177·07	4-10-43	5-2-48
Do. . . .	50. Shri Oke Brothers, Nagpur .	Felspar . .	Q. L.	7·92	18-2-42	1948

Do.	51. Shri Nathani Brothers, Raipur.	Calcite	M. L.	44·38	9-4-47	9-6-48
Do.	52. Shri Buddhoolal Jagannath, Panara, P. O. Junnordeo, Dt. Chhindwara.	Coal	M. L.	197·73	24-9-34	1948
Hoshangabad	53. Chowdhary Daulatsingh	Do.	P. L.	799·19	27-4-47	27-4-48
Do.	54. Shri P. V. Dutt	Soapstone	Q. L.	2·00	3-8-42	1948

MADRAS.

Pudukkottai	55. P. L. Vellaichami	Granite	Q. L.	4·58	July '47	30-6-48
Do.	56. G. Seshadri Naidu	Do.	Q. L.	·75	Do.	Do.
Do.	57. A. Muthayya Konar	Do.	Q. L.	2·00	Do.	Do.
Do.	58. Roman Servai	Do.	Q. L.	·50	Do.	Do.
Do.	59. S. Vaithinatha Iyer	Limestone	Q. L.	10·00	Do.	Do.
Do.	60. M. Sengole Udayar	Granite	Q. L.	3·95	Do.	Do.
Do.	61. P. Sayyed Ibrahim Ravuttar	Do.	Q. L.	·50	Do.	Do.
Do.	62. N. S. Sm. Swamikannu Pillai	Do.	Q. L.	6·00	Do.	Do.
Do.	63. M. Muthuvelu Servai	Do.	Q. L.	1·00	Do.	Do.
Do.	64. S. Muhammad Ibrahim Ravuttar.	Do.	Q. L.	1·50	Do.	Do.
Do.	65. S. Palaniandi	Do.	Q. L.	7·50	Do.	Do.
Do.	66. N. S. Sm. Swami Kannu	Do.	Q. L.	·70	Do.	Do.

P. L.=Prospecting License.
M. L.=Mining Lease.
Q. L.=Quarry Lease.

DETAILS OF MINERAL CONCESSIONS TERMINATED—*contd.*

Statement of Mineral Concessions terminated during the year ending 31st December, 1948—contd.

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of termination.
Pudukkottai .	67. S. Karuppayya Servai . .	Granite	Q. L.	2·70	July '47	30-6-48
Do. . .	68. P. Sayyed Ibrahim Porattar .	Do.	Q. L.	6·00	Do.	Do.
Do. . .	69. K. C. S. Abdulla Ravuttar .	Do.	Q. L.	2·30	Do.	Do.
Do. . .	70. N. S. Sm. Swami Kannu Pillai.	Do.	Q. L.	1·20	Do.	Do.
Do. . .	71. K. K. P. Sd. Ibrahim Ravuttar.	Do.	Q. L.	2·00	Do.	Do.
Do. . .	72. P. Sd. Ibrahim Ravuttar .	Do.	Q. L.	1·50	Do.	Do.
Do. . .	73. N. S. S. M. Swami Kannu Pillai.	Do.	Q. L.	·50	Do.	Do.
Do. . .	74. A. Santanam Pillai . .	Do.	Q. L.	6·00	Do.	Do.
Do. . .	75. M. Muthayya Pillai . .	Do.	Q. L.	2·50	Do.	Do.
Do. . .	76. N. S. S. M. Swami Kannu Pillai.	Do.	Q. L.	1·09	Do.	Do.
Do . .	77. P. Subramanian Chettiar .	Do.	Q. L.	4·82	Do.	Do.

Do.	78. V. R. M. Lakshmanan Chettiar.	Do.	Q. L.	·19	Do.	Do.
Do.	79. A. Singarayar Pillai	Do.	Q. L.	3·00	Do.	Do.
Do.	80. V. R. M. Lakshmanan Chettiar.	Do.	Q. L.	·15	Do.	Do.
Do.	81. C. Sandappa Thevar	Do.	Q. L.	7·12	Do.	Do.
Do.	82. Do.	Do.	Q. L.	2·25	Do.	Do.
Do.	83. V. R. M. Lakshmanan Chettiar.	Do.	Q. L.	3·65	Do.	Do.
Do.	84. P. Sd. Ibrahim Ravuttar	Do.	Q. L.	2·10	Do.	Do.
Do.	85. N. S. N. M. Swamikkannu Pillai.	Do.	Q. L.	1·10	Do.	Do.
Do.	86. C. Sundappa Thevar	Do.	Q. L.	1·5	Do.	Do.
Do.	87. P. Sd. Ibrahim Ravuttar	Do.	Q. L.	1·00	Do.	Do.
Do.	88. S. Thanukkodi Servai	Do.	Q. L.	1·2	Do.	Do.
Do.	89. R. Muthayya Servai	Do.	Q. L.	6·00	Do.	Do.
Do.	90. P. Chidambaram	Do.	Q. L.	·30	Do.	Do.
Do.	91. P. Chinnayya Konar	Do.	Q. L.	1·20	Do.	Do.
Do.	92. A. Nallayya Nayakar	Do.	Q. L.	35·57	Do.	Do.
Do.	93. M. Palaniandi Ambalam	Do.	Q. L.	2·40	Do.	Do.
Do.	94. V. Vaithilinga Servai	Do.	Q. L.	2·05	Do.	Do.
Do.	95. P. Subbayya Ambalam	Do.	Q. L.	1·50	Do.	Do.

Q. L.=Quarry Lease.

DETAILS OF MINERAL CONCESSIONS TERMINATED—*contd.*

Statement of Mineral Concessions granted during during the year ending 31st December, 1948—contd.

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of termination.
Pudukkottai	96. K. Ponnayya Naickar	Granite	Q. L.	1·15	July '47	30-6-48
Do.	97. M. Muthan	Do.	Q. L.	7·89	Do.	Do.
Do.	98. N. Mookan	Do.	Q. L.	·42	Do.	Do.
Do.	99. A. Mayandi Konar	Do.	Q. L.	1·00	Do.	Do.
Do.	100. M. Subramania Ambalam	Do.	Q. L.	·20	Do.	Do.
Do.	101. R. Sabapathi Chittiar	Do.	Q. L.	2·20	Do.	Do.
Do.	102. S. Ayyakannu Pillai	Do.	Q. L.	2·50	Do.	Do.
Do.	103. P. Muthukkaruppa Kandiar	Do.	Q. L.	1·15	Do.	Do.
Do.	104. M. Arunachala Udayar	Do.	Q. L.	·10	Do.	Do.
Do.	105. K. Nallayya Malavarar	Do.	Q. L.	·30	Do.	Do.
Do.	106. K. Rangaswami Alambirivar	Do.	Q. L.	·55	Do.	Do.
Do.	107. B. Maruthamuthu Kathavadi	Do.	Q. L.	3·00	Do.	Do.
Do.	108. M. Arunachala Udayar	Do.	Q. L.	·20	Do.	Do.
Do.	109. S. Sengole Pillai	Do.	Q. L.	·50	Do.	Do.

Do . . .	110. A. Karuppayyapali . .	Do	Q. L.	·43	Do.	Do.
Do. . . .	111 M. Sembattayya Natrayar .	Do.	Q. L.	45·93	Do.	Do.
Do. . . .	112. K. Doraichami Servai . .	Do.	Q. L.	176·03	Do.	Do.
Do. . . .	113. Kaveri Spinning and Weaving Mills.	Do.	Q. L.	2·27	Do.	Do.
Do. . . .	114. K. Nallayya Solangathevar .	Do.	Q. L.	6·97	Do.	Do.
Do. . . .	115. K. Nallayya Solangathevar .	Do.	Q. L.	2·20	Do.	Do.
Do. . . .	116. E. Thangavelu Nayudu .	Do.	Q. L.	1·52	Do.	Do.
Do. . . .	117. Do.	Do.	Q. L.	·95	Do.	Do.
Do. . . .	118. V. Singamuthu . . .	Do.	Q. L.	14·80	Do.	Do.
Do. . . .	119. G. Nallaswami Chettiar .	Do.	Q. L.	·50	Do.	Do.
Do. . . .	120. N. R. Sengole Pillai . .	Do.	Q. L.	1·74	Do.	Do.
Do. . . .	121. V. Dorachami Pillai . .	Do.	Q. L.	2·12	Do.	Do.
Do. . . .	122. S. Muthayya Servai . .	Do.	Q. L.	130·27	Do.	Do.
Do. . . .	123. C. Renga Konar . . .	Do.	Q. L.	(a)	Do.	Do.
Do. . . .	124. A. Sheik Adam Ravuttar .	Do.	Q. L.	(a)	Do.	Do.
Do. . . .	125. S. Kailasam Kaduvettiar .	Do.	Q. L.	·82	Do.	Do.
Do. . . .	126. N. Subba Nayakar . .	Do.	Q. L.	·43	Do.	Do.
Do. . . .	127. G. Renga Nayakkar . .	Do.	Q. L.	7·75	Do.	Do.
Do. . . .	128. S. Sundara Nayakkar . .	Do.	Q. L.	2·5	Do.	Do.

Q. L.=Quarry Lease.
(*a*) Not known.

DETAILS OF MINERAL CONCESSIONS TERMINATED—*contd.*

Statement of Mineral Concessions terminated during the year ending 31st December, 1948—contd.

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of termination.
Pudukkottai	129. G. Renga Nayakkar	Granite	Q. L.	1·49	July, 1947	30-6-48
Do.	130. M. Subbanambalagarar	Do.	Q. L.	·80	Do.	Do.
Do.	131. K. Palamiandi Ambalam	Do.	Q. L.	1·20	Do.	Do.
Do.	132. A. Arulananda Udayar	Do.	Q. L.	6·07	Do.	Do.
Do.	133. V. Ellappa Nayakkar	Do.	Q. L.	5·92	Do.	Do.
Do.	134. R. Subramania Ayyar	Do.	Q. L.	2·66	Do.	Do.
Do.	135. M. Kandaswani Muthiriar	Do.	Q. L.	1 24	Do.	Do.
Do.	136. P. Pichchaimuthu Natrrpaiyar.	Do.	Q. L.	6·36	Do.	Do.
Do.	137. T. Palaniandi Kudumban	Do.	Q. L.	3·75	Do.	Do.
Do	138. M. Irulan	Do.	Q. L.	·23	Do.	Do.
Do.	139. S. Saheo Ravuttar	Do.	Q. L.	·60	Do.	Do.
Do	140. M. Chimaya Kavandan	Do.	Q. L.	1·25	Do.	Do.
Do.	141. A. Kanthappa Navalangi	Do.	Q. L.	·80	Do.	Do.

Do.	142. Do.	Do.	Q. L.	·50	Do.	Do.
Do.	143. G. Renga Nayakkar	Do.	Q. L.	1·25	Do.	Do.
Do.	144. V. C. C. Sowri-muthudayar	Do.	Q. L.	·70	Do.	Do.
Do.	145. Palaniandi Udayar	Do.	Q. L.	·15	Do.	Do.
Do	146. Guruswami Nayakkar	Do.	Q. L.	31·03	Do.	Do.
Do.	147. M. Raju Asari	Do.	Q. L.	1 50	Do.	Do.
Do.	148. P. Karuppayya Tennatiriyar	Do.	Q. L.	1·64	Do.	Do.
Do.	149. P. Chimayya Malavarar	Do.	Q. L.	·10	Do.	Do.
Do.	150. S. Shanmughanathan Servai	Do.	Q. L.	·25	Do.	Do.
Do.	151. P. Pambaya Udayar	Do.	Q. L.	1·09	Do.	Do.
Do.	152. S. Narayana Nayakkar	Do.	Q. L.	(a)	Do.	Do.
Do.	153. Kamveri Weaving and Spinning Mills.	Do.	Q. L.	(a)	Do.	Do.
Do.	154. R. Mookayan Balandar	Do.	Q. L.	(a)	Do.	Do.
Do.	155. T. Poomalai Kandiar	Do.	Q. L.	(a)	Do.	Do.

Q.L. =Quarry Lease.
(a) Not known.

DETAILS OF MINERAL CONCESSIONS TERMINATED—*contd.*

Statement of Mineral Concessions terminated during the year ending 31st December, 1948—contd.

MADRAS—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of termination.
Pudukkottai	156. C. Ramayya Asari	Granite	Q. L.	(*a*)	July, 1947	30-6-48
Do.	157. N. Muthia Thengondar	Do.	Q. L.	(*a*)	Do.	Do.
Do.	158. R. Valarthar Malavarar	Do.	Q. L.	(*a*)	Do.	Do.
Do.	159. Abdulla Ravuttar	Do.	Q. L.	(*a*)	Do.	Do.
Do.	160. M. Palariappan	Do.	Q. L.	(*a*)	Do.	Do.
Do	161. V. Kathirbava Ravuttar	Do.	Q. L.	(*a*)	Do.	Do
Do.	162. A. S. Vaidyanatha Ayyar	Do.	Q. L.	(*a*)	Do.	Do.
Do.	163. M. Kaliaperamal Konar	Do.	Q. L.	(*a*)	Do.	Do.
Do.	164. M. Abdul Rahim Sahib	Do.	Q. L.	(*a*)	Do.	Do.
Do.	165. V. Kathar Bava Ravattar	Do.	Q. L.	(*a*)	Do.	Do.
Do.	166. A. Palaniaudi Nayakar	Do.	Q. L.	(*a*)	Do.	Do.
Do.	167. P. Natesa Pillai	Do.	Q. L.	(*a*)	Do.	Do.
Do.	168. Raman Servai	Do.	Q. L.	(*a*)	Do.	Do.
Do.	169. A. Nallayya Naicker	Do.	Q. L.	(*a*)	Do.	Do.

ORISSA

Sundergarh	170. Seth Deokaran Das Sundergarh.	Manganese ore	P. L.	349.13	15-3-47	14-3-46

MYSORE

Bangalore	171. V. L. Venugopal	Kaolin	P .L.	960	18-6-47	18-6-48
Hassan	172. P. S. Narayana	Corundum	P. L.	1,280	27-9-47	27-9-48
Do.	173. Do.	Staurolite	P. L.	2,560	20-10-47	27-10-48
Do.	174. Do.	Soapstone. Corundum, Kyanite, Staurolite. Graphite, Asbestos.	P. L.	1,920	6-5-47	5-5-48
Kolar	175. V. Krishnamurthy Rao	Kaolin	P. L.	320	27-11-47	27-11-48
Do.	176. C. A. Abdul Rahim	Do.	P. L.	320	30-11-47	30-11-48

Q. L.=Quarry Lease.
P. L.=Prospecting License.
(a) Not known.

DETAILS OF MINERAL CONCESSIONS TERMINATED—*contd.*

Statement of Mineral Concessions terminated during the year ending 31st December, 1948—contd.

MYSORE—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of termination.
Kolar	177. M. J. Rasheed	Corundum, Garnet and Coal	P. L.	320	13-5-47	13-5-48
Do.	178. B. K. Narayan Singh	Agate, quartz, Amethyst	P. L.	320	30-11-47	30-11-48
Mysore	179. Do.	Mica and Garnet	P. L.	640	Do.	Do.
Tumkur	180. P. S. Narayana	Corundum	P. L.	2,560	17-9-47	17-9-48
Do.	181. G. Chennabasappa	Soapstone	P. L.	(*a*)	30-10-47	30-10-48
Do.	182. T. L. Narasinghbhan	Do.	P. L.	(*a*)	15-12-47	15-12-48

KASHMIR

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of termination.
Doda	183. Wazir Tej Ramji	Sapphire	M. L.	216	1-4-45	30-3-48

PATIALA AND EAST PUNJAB STATES UNION

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of termination.
Dhanauri	184. Messrs. United Minerals Ltd., 2, Dalhousie Square, Calcutta.	Lead	P. L.	170	18-11-47	17-11-48

HYDERABAD

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of termination.
Adilabad	185. Messrs. Taj Clay Works, Ltd.	White clay	Q.L.	63	3-12-47	2-12-48

RAJASTHAN

Banswara	186. R. B. Seth, Kachorimal Sukhlal, Chhindwara, C. P.	Galena	P. L.	100	15-5-46	14-5-48
Do.	187. Pandya Shah & Co., Anand	Do.	P. L.	2,000	6-2-46	5-2-48
Jaipur State	188. Vidya Parkash Khosla	Clay	M. L	640	1-9-47	31-8-48
Do.	189. Shyamsunder Lal	Limestone	M. L.	640	Do.	Do.
Do.	190. Vidya Parkash Khosla	White clay	M L.	1,920	Do.	Do.
Do.	191. Shyam Sunder	Clay	M. L.	2,880	Do.	Do.
Do.	192. Pirbhu Dayal	Yellow Ochre	M. L.	640	Do.	Do.
Do.	193. Govind Narain	Limestone	M. L.	640	Do.	Do.
Do.	194. Vidya Parkash Khosla	Soapstone	M. L.	640	Do.	Do.
Do.	195. Do.	Yellow Ochre	M. L.	640	Do.	Do.
Do.	196. Prahlad Dass	Glass sand	M. L.	160	Do.	Do.
Do.	197. Manmohan Gupta	Lime stone	M. L.	·91	Do.	Do.
Do.	198. Shyam Sunder	Clay	M. L.	640	Do.	Do.
Do.	199. Sri Ram	Whiteclay Red Ochre	M. L.	1,920	Do.	Do.
Do.	200. Bhonri Lal	Limestone	M. L.	640	Do.	Do.
Do.	201. Narain Prashad	Yellow Ochre	M. L.	640	Do.	Do.
Do.	202 Bhonrilal	Limestone	M. L.	1,280	Do.	Do.
Do.	203. Damodar Lal	Do.	M. L.	640	Do.	Do.
Do.	204. Vidya Parkash Khosla	Clay	M. L.	640	Do.	Do.

P. L.=Prospecting Licence.
M. L.=Mining Lease.

Q. L.=Quarry Lease.
(a) Not known.

DETAILS OF MINERAL CONCESSIONS TERMINATED—*contd.*

Statement of Mineral Concessions terminated during the year ending 31st December, 1948—contd.

RAJASTHAN—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of termination.
Jaipur	205 Govind Narain	Limestone	M. L.	320	1-9-47	31-8-48
Do.	206. Padamchand Bhagchand	Soapstone	M. L.	640	1-12-47	1-6-48
Do.	207. Sohanlal	Limestone	M. L.	640	1-9-47	31-8-48
Do.	208. Ramdeo	Do.	M. L.	2,880	Do.	1948
Do.	209. Shivram	Do.	M. L.	640	Do.	31-8-48
Do.	210. Do.	Do.	M. L.	640	Do.	Do.
Do.	211. Narain Parshad	Red Ochre	M. L.	640	Do.	Do.
Do.	212. Chaterbhuj Kalyan Parshod.	Do.	M. L.	960	Do	Do.
Do.	213. Narain Parshad	Silica	M. L.	640	1-10-47	Do.
Do.	214. Do.	Yellow Ochre	M. L.	320	1-12-47	1-9-48
Do.	215. Do.	Silica	M. L.	640	1-9-47	31-8-48
Do.	216. Hari Kishan	Clay	M. L	1,600	Do.	Do.
Do.	217. Rampartab Saidmal	Limestone	M. L.	640	16-9-47	July, 48

Do.	218. Kartar Singh	Do.	M. L.	640	Do.	Do.
Do.	219. Vidya Parkash	Soapstone	M. L.	640	1-9-47	31-8-48
Do.	220. Srigopal Bihani	Mica	M. L.	640	1-10-47	31-9-48
Do.	221. Daudayal Mohta	Do.	M. L.	640	Do.	Do.
Do.	222. Sitaram Sodhani	Do.	M. L.	640	Do.	Do.
Do.	223. Do.	Do.	M. L.	640	Do.	Do.
Do.	224. Do.	Do.	M. L.	640	Do.	30-9-48
Do.	225. Do.	Do.	M. L	640	Do.	Do.
Do.	226. Do.	Do.	M. L.	640	Do.	Do.
Do.	227. Sree Bux	Do.	M. L.	640	1-9-47	31-8-48
Do.	228. Daudayal Mohta	Do.	M. L.	640	Do.	Do.
Do.	229. Do.	Do.	M. L.	640	Do.	Do.
Do.	230. Srigopal Bilani	Do.	M. L.	640	1-11-47	31-10-48
Do.	231. Damodar Dass Khandelwal	Red Ochre	M. L.	640	Do.	Do.
Do.	232. Rahul Limited	Limestone	M. L.	160	1-2-45	31-1-48
Do.	233. Do.	Do.	M. L.	1,280	1-6-45	31 5-48
Do.	234. Shri Sahai Grinding Mill	Soapstone	M. L.	640	1-10-45	30-9-48
Do.	235. Shrigopal Bihani	Mica	M. L.	640	1-12-47	30-11-48
Jodhpur	236. Ramlal Kachhawa & Sons	Yellow Ochre	P. L.	640	17-4-46	16-4-48

M. L.=Mining Lease.
P. L.=Prospecting Licence.

DETAILS OF MINERAL CONCESSIONS TERMINATED—*contd.*

Statement of Mineral Concessions terminated during the year ending 31st December, 1948—concld.

RAJASTHAN—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Date of termination.
Jodhpur . .	237. Mohamad & Sons . .	Red Ochre	P. L.	80	1-8-46	30-7-48
Do. . . .	238. Messrs. Mool Chand Kherajmal.	Black Ochre	P. L.	35	1-9-47	31-8-48
Kishangarh . .	239. The Hind Mineral Co., Kishangarh.	Mica	P. L.	92·42	31-10-47	30-10-48
Udaipur . .	240. R. B. Seth Moolchand Suganchand, Udaipur.	Emerald	P. L.	6,200	10-11-47	9-11-48
Do. . . .	241. The Mewar Industrial and Commercial Syndicate Ltd., Udaipur.	Do.	P. L.	3,200	1-2-47	31-1-48
Do. . . .	242. Do.	Do.	P. L.	3,200	4-4-47	3-4-48
Do. . . .	243. R. B. Seth Moolchand Suganchand, Udaipur.	Blue Sapphire . . .	P. L.	3,200	11-4-47	10-4-48
Do. . . .	244. Ruby Mining Syndicate, Udaipur.	Corundum	P. L.	3,200	22-6-47	21-6-48
Do. . . .	245. The Metal Corporation of India Ltd., Calcutta.	Lead, Zinc and Silver . .	P. L.	..	24-10-45	23-10-48
Do. . . .	246. The Mewar Mineral Co., Ltd., Udaipur.	Mica	P. L.	..	13-3-47	12-3-48

Do. . . .	247. Shri Bhanwarlal Jagetia, Pur	Garnet	P. L.	1,440	19-7-47	18-7-48
Do. . . .	248. Messrs. A. K. Tehsin & Sons, Ltd., Udaipur.	Garnet and Kyanite . .	P. L.	1,280	26-8-47	25-8-48
Do. . . .	249. R. B. Seth Moolchand Suganchand.	Corundum	P. L.	3,200	14-10-47	13-10-48
Do. . . .	250. Dewan Bahadur Seth Kesrisinghji, Kotah.	Emerald	P. L.	3,200	31-10-47	30-10-48
Do. . . .	251. R. B. Seth Moolchand Suganchand, Udaipur.	Mica	M. L.	Whole of sub-dist. Bhim.	1-4-43	31-3-48

VINDHYA PRADESH

Sohawal . .	252. Sheoratanlal Jaitwara .	Ochre	P. L.	25	22-1-47	22-1-48
Do. . . .	253. Bholanath Murarka Jaitwara	Do.	P. L.	10	23-1-47	Do.
Do. . . .	254. Do.	Do.	P. L.	10	9-1-47	Do.

P. L.=Prospecting License.
M. L.=Mining Lease.

RECORDS
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Volume 82] 1954 [Part 4

THE SLATES OF CUMBUM AND MARKAPUR, KURNOOL DISTRICT.* By M. S. KRISHNAN, PH.D., A.R.C.S., F.N.I., M. S. BALASUNDARAM, M.A. AND K. JACOB, D.SC., F.N.I., *Geological Survey of India.* (With Plate 17.)

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Indian Agricultural Research Institute

The slate belt of Cumbum and Markapur lying on the border of the Nellore and Kurnool districts, Madras was examined in detail during the field seasons 1939-40 and 1943-44. The purpose of the investigation was to find out whether slates of good quality, similar to those occurring within the limits of the Venkatagiri Zamindari, exist in the adjoining areas directly under the control of the Government of Madras. The best deposits of the region are found in the Zamindary (in the Nellore district), but continue south-westwards to Obanayanipalle and beyond.

This paper is divided into two parts, the first dealing with the general characters of slate, its working and uses and the second with the slates of the Cumbum-Markapur region.

GENERAL CHARACTERS OF SLATE

NATURE

The name *slate* is applied to a rock which was originally laid down in water as fine clay or silt and which has later been indurated, compressed and metamorphosed with the development of excellent cleavage. It is this cleavage which is characteristic of slate and distinguishes it from other rocks derived from sediments. The degree of compression more or less determines the perfection of the cleavage and also whether the product becomes a shale, slate or schist. A comparatively lightly compressed argillaceous sediment produces a shale or a clay slate which is soft, poorly cleaved and easily weathered. On the other hand, a highly metamorphosed clay is thoroughly recrystallized into a schist in which the minerals are coarse and the cleavage planes irregular and far from smooth.

COMPOSITION

Mineral composition.—The most important minerals found in slate are sericite (a very fine grained form of muscovite mica), chlorite and quartz. Amongst the other minerals mention may be made of biotite (black mica), hæmatite, limonite, carbonates, carbonaceous matter and graphite, rutile, pyrite, andalusite, and magnetite. According to the abundance of certain of these minerals, slates may become carbonaceous, ferruginous, calcareous and siliceous.

T. N. Dale (1914) in his well known work on the slates of the United States of America, gives the average mineral composition of a number of French slates as below:—

	PER CENT.
Muscovite (sericite)	38—40
Quartz	31—45
Chlorite	6—18
Hæmatite	3—6
Rutile	1—1·5

The minerals are usually platy, fibrous or granular in habit and of fine grain except in knots and bands. The platy minerals like *mica* and *chlorite* are arranged with their flat surfaces parallel to the cleavage plane and their length along the direction the degree of perfection of the parallelism determine the fineness of the cleavage. A few minerals such as pyrite, graphite and andalusite tend to segregate into knots which may cut through or buckle up the cleavage planes.

Chemical composition.—Slates are chiefly made up of silica, alumina and iron oxide which together make up the bulk of the material. Minor amounts of lime, magnesia, alkalies and titania, etc., are also frequently present. The following range of percentage of constituents is known—

	PER CENT.
SiO_2	35—65 (Mostly around 55—60).
TiO_2	0·3—0·9
Al_2O_3	12—25
Fe_2O_3	1—6
FeO	
CaO	0·2—15
MgO	1—6
Na_2O	1—6
K_2O	
H_2O+	1·5—4

Some slates may be characterised by an abundance of particular constituents such as iron oxide, calcium carbonate or silica.

Colour.—Slates occur in a fairly wide range of colours, but the large majority are grey to black. Greenish, purplish and bluish black tinges are common, the bluish grey colour being often referred to as slate-grey. The greenish colour is generally attributable to much chlorite, the black to carbonaceous matter and the red and purple to a high content of ferric iron.

When exposed to the weather, the original colour of the slate may become modified to varying extent. The black and dark grey colours are more or less permanent but may fade slightly after long exposure. Red and purple slates have a tendency to become brown or rusty owing to oxidation of the iron content Greenish slates are generally more prone to change colour than others.

This general rule does not apply in all cases, for slates of green and purple colours are known which are practically permanent. The cause of fading and change of colour is the mineralogical change that is brought about by exposure to the weather. Carbonaceous matter is liable to oxidation when the colour fades. Pyrite and marcasite if present, oxidise rapidly, setting free sulphuric acid and limonite, the latter spreading as a brown colour and the former attacking the slate itself and producing a clayey substance. When carbonates are present, they are attacked by the acid dissolved from the atmosphere by rain water, resulting in slow disintegration of slate and in colour changes. The change of colour does not necessarily indicate a defect provided it is uniform and slow and there is no formation of unsightly blotches. Some natural slates have mottled and variegated colours which, if pleasant, have an artistic effect.

Density.—The average density (specific gravity) of slate is between 2 6 and 2 8.

Hardness.—This property varies somewhat from bed to bed and from place to place. The average slate has a hardness of 3 to 4 on Moh's scale widely used by mineralogists. Some highly siliceous slates may however be harder whereas clay-slates are softer.

ORIGIN OF SLATE

All slates are of sedimentary origin and were originally deposited in bodies of water as clays and silts composed of quartz, clay minerals, carbonaceous, calcareous, siliceous and ferruginous matter some of which may have been in a colloidal condition.

The sediments are first compacted by the pressure of overlying strata. Most of the water is then pressed out and the material becomes a shale. When the shales are compressed by tangential pressures due to earth movements, they become slates and develop cleavage in a direction perpendicular to the compression. A certain amount of pressure by superincumbent strata is also necessary to prevent the plastic material flowing upwards. Otherwise flowage may occur and not recrystallisation and slaty cleavage. New minerals are built up during this stage, and they include sericite, chlorite, limonite, hæmatite, etc. The degree of perfection of the cleavage depends on the fineness and uniformity of the shale and the amount of pressure. The platy minerals become arranged with their flat surfaces parallel to the cleavage. The strata are thrown into folds, the cleavage being finally superimposed on the folded strata irrespective of the direction of the bedding planes.

The best slates are formed from homogeneous finegrained shales. In non-homogeneous material the coarser and harder beds are crushed and the softer beds tend to flow and fill up the irregularities. There is a movement of the molecules in a direction perpendicular to the compression and the new minerals are built up by these in consonance with the space available.

When clays are compressed under very deep conditions where pressure and temperature are high, they may attain a still higher stage of metamorphism and become phyllites or schists. No quantitative estimates of depth are possible, but Behre (1933) states that the slates of Pennsylvania have probably been formed at a depth of between 8,000 and 20,000 feet.

STRUCTURAL FEATURES

Bedding.—Slate being a sedimentary rock, the quality varies between one bed and another. Any abnormal variation in the composition of a particular bed makes it conspicuous, giving rise to a 'sandy bed' or 'ribbon'. When there are several thin beds of non-uniform character, the cleavage is not perfectly developed and splitting yields rather uneven and irregular slabs. The harder beds also tend to stand up when the slabs are planed and polished.

Ribbons.—Ribbons are dark layers or bands seen across the cleavage planes. If they contain much carbon, they make the slate unfit for electrical work. Ribboned slates do not weather uniformly if the minerals giving rise to them are of different hardness from the rest of the slate. Ribboned slates are sometimes in demand for decorative purposes.

Knots.—Knots are small clots of some minerals which have become aggregated into rounded inclusions. They may consist of quartz, carbonates, silicates, magnetite, etc. If they are conspicuous and large, they may present difficulties in obtaining smooth slabs and in actual utilization.

Folds.—Slate formations generally show folding into series of anticlines and synclines, with minor folds within certain soft individual beds. If the folding is uniform, the axial planes are parallel and similar limbs of the folds show similar dips. There is always a tendency for the beds to thicken at the crests and troughs and in these regions the cleavage becomes irregular and the slate may be unusable.

In general, the cleavage planes have a certain degree of parallelism to the axial planes of the folds since both these features result from the same earth movements. If, however, the slates have been subjected to a complex system of movements, the cleavage may show other special features.

Sharp folds and the presence of numerous hard beds in the slates may make them worthless for exploitation. If the folding is comparatively 'open' it does not affect the quality and structure of the slate.

Faults.—Slates develop considerable plasticity under pressure and hence do not generally show faulting, unless there are well marked hard bands in them. Faults may, however, be observed sometimes, and these may be marked by veins of quartz.

Cleavage.—The property of cleaving or separating into thin layers or slabs is characteristic of slates. It is due to the tight compression and the development of platy minerals which have their flat surface parallel to the cleavage plane and their length along the direction of grain. The cleavage is always at right angles to the direction of the final compression and practically parallel to the axis of folding.

The cleavage planes in good slates should be really plane surfaces. One sees however, a slight curvature or bend on these planes, this being due either to some late earth movement or to irregularities in the resistance offered by different beds to compression. In immediate vicinity of hard beds (*e.g.*, sandy or flinty beds) the slate is often found to have 'flowed' like a soft material and developed irregular cleavage. This phenomenon can be seen near the tops of most of the ridges in the slate belt of Markapur where hard quartzite beds are present. Cleavage planes may sometimes be buckled or crinkled to a greater or lesser extent. Buckled slates could be used for some purposes, but fractured or sheared slates are of little use.

The true direction and dip of the cleavage are usually masked by slumping on hill sides. But when the surface material is removed and the fresh slate exposed the true features are clearly seen.

The attitude and dip of the cleavage is of importance in quarrying. If the cleavage is steep it is difficult to use the channelling machine or even the wire-saw. But in hand mining steep dips are not a hindrance if the development of the quarrying is intelligently done.

Joints.—Most rocks are jointed, *i.e.*, separated into blocks naturally by fairly regular and large scale planes of separation. Joints are not always regular and in smooth planes. They are generally formed after the cleavage and are features developed during the final adjustments of the rock masses in the earth's crust. In slates they are often related to the original bedding planes, grain direction, etc.

Joints are of considerable importance in quarrying for the blocks which separate most easily along them. If they are regularly spaced at convenient intervals, they facilitate the easy removal of the slate in blocks of useful size. If they are too close together, say less than two feet from each other, large slabs cannot be mined.

Joints are also a source of trouble since it is along them that surface waters find their way underground and weather and stain the slates in their immediate vicinity. The joint planes may be heavily iron-stained or encrusted with calcium carbonate or silica. They also help in slumping if the slate crops out on a sloping surface.

Slates with moderate and nearly rectangular jointing are easy to work and without much wastage in preparation. If the different sets of joints meet at acute angles, there will be much wastage since the slabs have to be cut into rectangular shapes.

Grain.—The direction of the 'grain' is one along which slate breaks easily, next to that of the cleavage and joint. This direction is generally easy to decipher in natural exposures and quarries, as it is indicated by faint long streaks or a kind of scarcely discernible fluting. If we take a fairly large quarried block, the two largest smooth surfaces are those of cleavage, the ends are joint planes, and the long, narrow, fairly straight side planes are those of grain. The direction of grain is parallel to that of the elongation of the fibrous and platy minerals, while the plane of breakage due to it is perpendicular to the cleavage plane. The grain direction has a greater electrical and heat conductivity than the one at right angles to it. This can be proved by coating a cleavage face of a piece of slate with wax and placing a hot needle at a number of regularly spaced points on this surface when a series of elliptical molten patches are produced. The long axes of the ellipses will be found to be parallel to each other and to the direction of grain. This phenomenon was first noticed by E. Jannetaz (1884).

The direction of grain is important in quarrying and in preparing the slate. Along it the slabs split easily and can be taken advantage of in dressing the blocks. In the factory one of the sides of the rectangular or square pieces must be made parallel to it in the final cutting and trimming. Strips for making slate pencils are also to be cut parallel to the grain as otherwise the strips will break into small pieces even during the preparation.

Blisters.—These are comparatively small and low bulges seen on the cleavage faces, with circular or elliptical outline. They may be up to a foot or two in diameter the highest point in the centre being an inch or two above the general surface and sometimes showing concentric step-like lines.

Slaunts.—There are often seen some parting planes having the same strike as the cleavage but somewhat inclined to the cleavage planes. In some cases at least they are the original bedding planes of the slate.

False cleavage.—Planes of false cleavage are indicated by lines or thin fissures and cracks on the cleavage planes, which are often related closely to the folding of the cleavage planes. Folds are sometimes crossed by such fractures which run parallel to the axis of the folds. In such cases the slate tends to break into thin pencil-like fragments. False cleavage is thought to be due to the close folding of the cleavage planes because of which the fibrous minerals are broken across by planes perpendicular to their length. False cleavage is a fairly common phenomenon especially near the crests and troughs of folds and in zones of shearing. This is not common in the portions of the slate belt of Markapur which have been opened up but may be seen in the acutely folded portions.

All these minor structures are deleterious features in slates.

The inter-relationship of the major structural features has considerable economic significance in working the slates. The best slates are usually those in which the bedding and cleavage tend to coincide since the material along the cleavage plane is then perfectly uniform in composition. On the limbs of folds, if the beds vary rapidly in composition, it may sometimes not be possible to get good blocks.

Grain planes and strike of bedding should preferably meet more or less at right angles in order that loss in trimming may be small, and that the blocks are as nearly free from ribbons as possible.

In a similar way the relationship between joints, cleavage planes and bedding has much influence on the nature of the blocks that could be mined. The quarried blocks should have as few ribbons as possible and should break into rectangular shapes which is possible only if the joints are practically parallel to the bedding.

WEATHERING OF SLATE

Slates generally contain a certain amount of water which enters from the surface along the joints, cleavage planes and bedding, and also along zones of crushing. This water is called quarry-water. When it accumulates in quarries it has to be drained off or pumped away according to local conditions. It should be kept in when it does not flow appreciably into the quarry, for the slate should be allowed to retain its natural moisture, as far as possible till it is quarried and removed.

Surface water percolating down into the beds usually produces discolouration, along joint planes. The part of the bed above the permanent ground water is subjected to alternate wetting and drying and to the action of the atmospheric gases and materials dissolved in the percolating waters. The changes that occur constitute weathering. They comprise a gradual change of colour, staining by products of decomposition, and breaking along cleavage planes. In the final stage of weathering, the minerals become disintegrated and decomposed and give rise to a clayey substance from which the alkalies and alkaline earths are removed while silica, alumina and iron tend to be concentrated.

TECHNOLOGY

Exploration.—The first stage in the exploration is the preparation of a geological map of the region showing the distribution of the different qualities. Though slate beds tend to retain their nature over appreciable distances along strike, it should be realized that they are also liable to variation.

Slates exposed at the surface are examined by trenching, and trenches should be deep enough to expose the unweathered slate. Then slabs should be collected for testing in the laboratory. If the bedding is easily made out, the trenches are best cut with their length across the strike of bedding, for a good thickness of the beds can then be examined.

If surface examination is difficult, core drilling may be resorted to. The cores will give information on the nature of the slate underground. If the structure permits, the drill holes may preferably be at right angles to the bedding planes. Dale says that, in general, the drill holes may be directed at an angle 45° to the dip of the cleavage, so that the sections of slates obtained will be elliptical and larger than the circular sections which would be got by drilling perpendicular to cleavage. According to Behre drilling is best done at right angles to either the strike of bedding or the strike of cleavage. On being brought to the surface, the drill cores should be immediately oriented carefully and properly marked before removing them for study.

Quarrying.—Slate quarries are so laid out that the sides are parallel to the strike of the cleavage and to the grain. The quarries may be quite long and broad if the slates are flat lying, but long and narrow if they are steep dipping. If such steep beds continue downwards without change of character, underground mining will have to be done after the limit of quarrying is reached.

In America, the stripping of the over-burden is done in most cases by means of steam shovels. The waste is dumped on areas where the slates are not workable. When the cleavage is very flat dipping, the channelling machine (track channeler) is used for cutting the slate. If the dip of cleavage is steep, this machine cannot be used and drilling and light blasting are resorted to.

The wire-saw is now widely used in slate quarrying. This is a three-strand cable having a diameter of 3/16 to ¼ inch, used as an endless wire. It is supported on an electrically-run drive pulley and sheaves mounted on standards. These standards are set in holes drilled into the slate at suitable locations. The cutting agent is sand fed with water. The wire-saw is a cheaper and more effective device than the channeler and has less shattering effect than the latter.

Milling and preparation.—The slate blocks are loosened from the quarry by the above-mentioned process and hoisted out. In modern quarries each block may be up to three or four tons in weight as it is raised from the quarry. After removing to the mill the blocks are split to convenient sizes if too large and sawn by large circular steel saws (36 inches or more in diameter and ⅜ inch thick) revolving in a vertical plane on a horizontal axis. The saw is fed with some good abrasive and revolves at a speed of 5 to 10 revolutions per minute. The slate is placed on a horizontal table with slots for directing the saw, the table moving gradually forward as the cutting proceeds. The rate of cutting varies from 3 to 20 inches per minute.

Splitting.—The slate blocks which have been reduced to about 5 or 6 inches in thickness and 2 or 3 square feet in area are sent to separate sheds for making into roofing slates. The blocks are slightly moistened if necessary and split by inserting thin and wide bladed wedges along the cleavage plane and tapping lightly by mallets. Mechanical splitters are said to be not as good as hand-splitting.

Trimming.—After splitting to proper thickness, which in roofing slates is generally 3/16 to ¼ inch, the slate is trimmed by a steel blade operated by a treadle (like a guillotine), to sizes needed for roofing or other purposes. Roofing slates are bored or punched for nail holes before they are stored for marketing.

In modern slate mills, the slate is graded before preparation and a series of power-driven saw and trimming machines are arranged in rows. The slate is supplied by travelling overhead cranes. The waste slate from cutting and trimming operations falls through chutes on to a depressed platform below the level of the machines wherefrom it is trimmed away. The factory has also storage space and possesses emery and carborundum wheels for sharpening tools and a carpentry shed for packing. Mill planes are discussed by Oliver Bowles in his bulletin on the technology of slate.

Planing.—Slates used for blackboards, school slates and electrical slates are planed, polished and well finished before marketing. The planing is done by a table which moves back and forth, carrying slate slabs under a blade which is set at a very small angle to the horizontal. The planing blade is shorter than the slab so that the slate has to be moved over different parts of the surface. The blade is so mounted that it can be adjusted to different heights.

Sand polishing.—Polishing of the planed surface is necessary for some purposes such as blackboards, school slates and electrical switch boards. The polishing is done on a 'rubbing bed' which is an iron disc of a suitable diameter (anything up to 10 feet in diameter) rotating on a vertical axis. Sand is used as the abrasive with water as lubricant. The slate to be polished is lightly pressed against the rotating disc until it becomes quite smooth.

A final polish may be given on a buffing machine which consists of several disc-shaped rubbing blocks which press on the slab to be polished by means of springs. The slate rests on the table of the machine and is moved so that the buffers polish all its surface evenly.

Finishing.—Drilling or punching of holes, levelling of the edges, grooving, etc., are done in the final stage preparation by hand or by mechanical devices.

USES

Roofing tiles.—The most extensive use of slate is in roofing for which the slabs are cut to several sizes ranging between 24 by 14 inches and 10 by 6 inches. The number of tiles required for covering 100 square feet with a 3-inch overlap varies from 100 to nearly 700. The standard thickness of roofing slate is 3/16 inch but those of ¼ and ⅜ inch are also produced. The weight of slate tiles necessary to cover 100 square feet of roof is in the neighbourhood of 700 lb.

Slates are designated 'clear' if of uniform shade and grain all through without ribbons, knots, etc. Other qualities are 'moderately ribboned' and 'heavily ribboned' slates. Only clear and moderately ribboned slates are ordinarily used for roofing, but heavily ribboned slates are sometimes used by architects for producing special artistic effects.

Blackboards.—Blackboards are made of large slabs 5 or 6 feet long. They are split carefully and planed and polished. They should be clear stock with as few ribbons as possible.

Billiard table tops are sometimes made of slate slabs which should be clear stock and planed and polished.

School slates.—These provide a fairly large outlet for slate which should be black, free from ribbons and fairly hard. The sizes vary from 14 by 10 to 8 by 6 inches, and the thickness usually 1/6, 1/7 or ⅛ inch. The slates are planed on both sides and then passed between two polishing cylinders revolving in opposite directions. The slates are washed thoroughly before framing. School slates used on the continent of Europe are machine-ruled and the grooves of the rulings coloured by red lead.

Electrical switch-boards.—Only specially high quality slate can be used for this purpose. The slate should be free from ribbons, knots, veins and inclusions of such conducting minerals as pyrite, magnetite and graphite. It should have a high resistance to the flow of electric current. Graphitic and carbonaceous slates are unsuitable for this purpose and only tested slates are used.

Structural.—Where slate is cheap as in quarrying districts it is often used as a structural material in the same way as bricks and stone. Slate is also used as tiles for lining walls and floors in bath-rooms, lavatories, etc. Slate flagging may be used for paving floors if sufficiently hard. Fencing may be constructed of slate slabs.

Marbleized slate.—Prepared slate slabs are artificially coloured in various patterns and the colouring burnt in by baking. They can also be coloured by lacquer and made to look like veined and variegated marbles. These are used for table-tops, and mantle pieces and as tiles for flooring or lining walls.

Granulated slate.—The waste material from slate quarries is crushed and sized and used for making roofs and flexible stone-coated shingle.

Pulverized slate.—Slate powder is widely used as a filler in plastic roofing, rubber and linoleum; in making asphalt road-surfacing; in cardboard and heavy wrapping paper; in abrasive soap and metal polish ; in cheap paints and colour-washes, chiefly of grey and brown colours.

TESTING OF SLATE

The chief tests applied to slates are colour and its constancy, sonorousness, density, hardness, toughness, porosity and absorption, cleavability, crushing strength, transverse strength, elasticity, resistance to corrosion and electrical resistance. Some of these characters are merely qualitative and others can be quantitatively determined.

Colour.—There are as yet no colour standards adopted for slate, though the U. S. Bureau of Standards has suggested a simple colour designation which includes the following: black ; blue-black ; grey ; blue-grey ; purple ; green ; mottled purple and green ; purple variegated ; red. Behre suggests that for descriptive purposes the standard colour charts devised by the National Research Council of the U.S.A. for sedimentary rocks may be adopted (M. I. Goldman and H. E. Merwin, 1928).

The constancy of colour is largely a matter of finding out by trial, but a microscopic examination of the mineralogical constitution may often give useful information on this point.

Sonorousness.—This is tested by suspending the slate by a string through a hole made near an edge and by giving it a sharp tap with a small hammer. Good slates have a metallic ring.

Density and Hardness are tested in the usual way followed for minerals in general. Sclerometers have been used for testing the hardness of slates.

Toughness.—The resistance offered by slate to fracture under impact is tested by allowing a hammer of 2 Kg. weight on pieces of prepared slate slabs of standard dimensions from different and gradually increasing heights until fracture takes place. The hammer falls on a plunger having a spherical head which rests on the piece tested.

Porosity and Absorption.—The porosity or amount of pore space in the given material is expressed as a volume relation by the formula: $P=100/d\ (d-a)$ where P=porosity ; d=true sp. gr.; a=apparent sp. gr. The apparent density is that ordinarily measured in the laboratory by one of the usual methods. The true density may be measured by crushing to a fine mass a known weight of the substance, immersing it in a known volume of a liquid and noting the resultant volume.

For measuring the absorption, sawn and planed pieces of uniform size are taken, washed and dried at 110° C. for several hours, cooled to room temperature and immediately weighed. The pieces are then immersed in water at room temperature for 48 hours, after which they are taken out, wiped with a dry cloth to remove the adhering water and weighed again immediately. The difference in weight divided by the initial weight and multiplied by 100 gives the percentage absorption:

$$\text{Absorption} = \frac{B-A}{A}(100)$$

where A is the first weight and B weight after immersion.

Absorption is an important factor since a porous slate absorbs water from rain or even from moist air and shows a tendency to spall especially if exposed to large variations of temperature.

Cleavability.—The ease with which a given slate cleaves in the hands of a skilled worker will give an idea of its value and usefulness. This is more or less qualitative.

Crushing Strength.—This property is not of importance in slates as they are rarely used as structural materials as in the case of other rocks. Crushing strength is tested on cubical pieces of certain standard sizes this being a routine test in engineering laboratories. Crushing strength is expressed as 'Kilograms per square centimetre' or 'Pounds (avoir.) per square inch'. It should be stated that the crushing strength is higher in a direction perpendicular to the cleavage than parallel to the cleavage.

Transverse strength is measured by the load necessary to rupture a slab. The American Society of Testing Materials method (1930) is as follows:—

> "Strips are cut to measure 12 inches long by 1½ inches wide parallel to the cleavage. They are rubbed down to a thickness of 1 inch, dried at 110° to 120° C. for 24 hours and then their length, width and thickness are measured in terms of inches to the nearest 0·01 inch. Each specimen is supported on two knife-edges 10 inches apart at centres and is loaded by another knife-edge midway in the span. The load is increased at the rate of 100 lb. per minute and each 50 lb. increment noted, Rupture is recorded at the nearest 5 lb.

Calculations for Mf (modulus of rupture) are based on the formula:

$$Mf=\frac{3\,wl}{2\,bd^2}$$

in which w is the breaking weight in lb., *l* the length of span in inches and d the thickness in inches. The tests should represent at least 3 experiments with strips cut with their lengths parallel to grain and three with their lengths transverse to the grain. Results should be reported as averages for each direction. Should any single test vary by more than 25 per cent. from the average of all like tests, it may be omitted."

Elasticity.—The usefulness of slate in large slabs depends on the property of elasticity. The modulus of the elasticity is determined on cleavage strips measuring 12 inches by 4 inches having a thickness of ⅝ inch. The test is done as in the case of the transverse strength, the load being increased at the rate of 100 lb. per minute, every 50 lb. increase being recorded. The deflection of the piece due to load is measured by means of a deflectometer reading accurately deflections of 0·001 inch.

A straight line graph is constructed and the value of E (the modulus of elasticity) obtained by using any convenient point on the curve and using the formula:

$$E=\frac{W\,l^3}{4\,d\,bt^3}$$

in which W=load at the selected point, d=the corresponding deformation as obtained on the curve, l=length of span in inches, b=width and t=thickness of the test specimens in inches. At least 3 pieces each, cut parallel and right angles to the grain should be tested and the average reported for each set.

Resistance to Corrosion.—Slates used as roofing material in chemical, fertilizer and acid works, in smelters and for laundry tubs have to be resistant to corrosion. No standard tests seem to have been adopted but accelerated tests using certain acids and alkalies have been conducted by some authorities. In general most slates are quite resistant to these for fairly long periods.

Electrical Resistance.—The tests are carried out in accordance with clause 4 of the British Standard Specification for slate and marble slabs for electrical power switchgear—No. 160 (1936). The following is an extract of the standard specification:—

"*Standard Test.*—This is a routine test for determining the insulation resistance through the thickness of any slab and shall be carried out by means of an exploring electrode with a D.C. voltage of about 500 volts applied for one minute at the temperature and humidity of the test room. The upper electrode shall consist of a solid cylinder of brass 1·2 inch in diameter and 1½ inches high. The sharp edges shall be removed from this electrode by turning so that the radius at the edge shall not exceed 1/32 inch, thus giving the portion of the electrode in contact with the slab a diameter of 1·3 inch or an area of one square inch.

The lower electrode shall be metal with round edges and of any convenient thickness, provided it is flat and of a diameter equal to twice the diameter of the upper electrode. Since the area of the exploring electrode is 1 square inch, the insulation resistance will be a function of the thickness."

PART II.

SLATES OF CUMBUM-MARKAPUR AREA

Area visited.—A large area around Markapur (15° 44′:79° 16′) and Cumbum (15° 34′ 30″:79° 6′ 30″) is occupied by slaty rocks but only a comparatively narrow belt of this contains slates of commercial value. This belt runs from Anantavaram (15° 47′: 79° 22′) to Tummalacheruvu (15° 40′:79° 17′ 30″) and continues thence to Pedda Obanayanipalle (15° 34′:79° 12′) east of Cumbum. The total length of the belt between the villages mentioned above is about 18 miles. The area lies in Survey of India topographical sheets 57 M/2, M/5 and M/6.

Geology.—The rocks of this area belong to the Cumbum Tank Quartzite (Bairenkonda stage) and Cumbum Slate (Cumbum Slate stage) of the Cuddapah System (Pre-Cambrian). They comprise quartzites and slates of different qualities ranging from greenish clay-slates with irregular and ill-developed cleavage, through pink, grey and dark slates of medium quality, to good dark grey ones. Intercalated with the slates are comparatively thin beds of slaty quartzites and massive to gritty quartzites.

Cumbum Tank Quartzite.—The Cumbum tank quartzite stretches in this area from 1½ miles west of Cumbum (57 M/2—15° 34′ 30″:79° 6′ 30″) north-eastwards for several miles and passes a little to the north-west of Markapur. It consists of parallel ridges, earthy brown in colour and almost bare of vegetation. These ridges are made up chiefly of quartzites, massive or flaggy, and sometimes even slaty, with intercalations of thin clay-slates. The quartzites strike N. 30°—40° E. to S. 30°—40° W. and dip towards E. 30°—40° S. at angles of around 60°. The beds are disturbed in the passes opposite to the Cumbum pumping station and the P.W.D. rest-house situated about 1½ miles west of Cumbum. Ripple marks are not uncommon in these quartzites. Weathering and crumpling sometimes produce structures simulating ripple marks. The quartzites are generally fine grained with waxy semi-vitreous lustre. Quartz veins are also noticed cutting across them. Associated with these, there are also sericitic, micaceous or talcose quartzites which have a satiny sheen on the cleavage surfaces.

Cumbum Slate.—The area east of the Cumbum tank quartzite ridge, extending from Cumbum to Markapur (57 M/6—15° 44′:79° 16′ 30″) and beyond, is composed of slates of the Cumbum Slate stage. The general strike of slaty cleavage in this region, N. 30° E.—S. 30° W., is also the regional strike of the rocks with the dip at high angles of 60°—85° towards E. 30° S Occasional dips in the opposite direction are also noticed. Though the strata have been undoubtedly folded, the folding is not clearly seen.

The direction of bedding of the slates is not distinct except at the following localities:—(1) Half a mile east of Nadimpalle (57 M/2—15° 36′:79° 8′ 45″) where the slate beds appear to dip S. 30° W. in the general direction of the cleavage strike of slates, (2) Half way along the road from the Markapur railway station to the town, on the right (eastern) side of the road where there is a well showing the dip directions of cleavage and bedding; the cleavage dip is 70°, E. 30° S. but the beds dip 40° in the same direction. (3) South-west of Bestavarapeta (57 M/2—15° 33′: 79° 6′) where the dip of cleavage planes is 65°, E. 30° S. while the dip of bedding is 30° in the same direction.

Most of the slates occurring in this part of the belt are clay-slates, sometimes siliceous. Some of the siliceous slates pass along the strike into slaty quartzites and it is often impossible to distinguish the two types. The slates are mostly greenish grey in colour with irregular and ill-developed cleavage. Slates of purplish and other shades of grey are also noticed but are less common. The greenish grey slates, the dominant type in this region, contain chlorite and sericite, sometimes with talcose material. The presence of these in the cleavage planes imparts a velvety appearance to the slate in reflected light. In the hills northeast of Cumbum the slates are generally iron stained.

The dark grey and black slates presumably contain fine carbonaceous or graphitic matter. Purplish and pinkish tints are fairly common in the slates being worked at present. Layers streaks or circular patches of these colours are also observed in some slates. Light grey or whitish patches are also noticed particularly in those from Anantavaram (57 M/5—15° 46′ 50″: 79° 22′)—Mallapeta (57 M/5—15° 49′ 10″:79° 22′ 30″) belt. The presence of these patches and streaks definitely lowers the quality of the slates.

The clay slates occurring near Cumbum are regularly quarried for use as building materials such as slabs for paving, roofing and fencing. As paving stones they are not very good as they wear unevenly.

The wide superficial display and the average dip of these slates suggests an enormours thickness but this is deceptive and may be due to folding. Boulders of vein quartz are sometimes seen occupying the slopes of hillocks of the slate belt. Near Katakampalle (57 M/6—15° 40′ 40″:79° 18′) they form little knolls or low hillocks. Probably these represent later intrusions in the slate belt and they are however barren of any mineral of economic importance.

Intercalations in Cumbum Slate—Quartzite intercalations.—Almost invariably every hill or hillock in the slate belt contains quartzite intercalations forming the axis or backbone of the ridge. These quartzites are massive, flaggy, or sometimes slaty. They are waxy in appearance, coarsely jointed, sometimes containing some white mica and talcose or chloritic matter. They bear a strong resemblance to those of the Cumbum tank ridge. Near Cumbum the quartzites, slaty quartzites and siliceous slates form a horse-shoe bend across the middle of the Cumbum plain. Beginning close to the northern end of the town the quartzite band strikes north and east and then turns south, cuts across the Gundlakamma, west of Motupalle (57 M/2—15° 35′ 50″: 79° 11′ 25″) and then continues southwards running parallel to Pulli Vagu. This band forms the crest of the hill 1130 (Yanegaykonda), 3 miles north-east of Cumbum. Half a mile north-east of Lanjakota (57 M/2—15° 36′ 20″:79° 10′ 15″) it exhibits well preserved ripple marks. When followed further northwards it shows a sharp bend near the temple on the top of Singaraya Konda (·980) and strikes southwards, ultimately getting lost in the Vemuleru valley.

Some of the slaty quartzite intercalation in the slate belt contain good stones for honing and abrasive purposes.

Limestone intercalations.—Interbedded with the Cumbum slates, there are also beds of limestone occurring near the foot of the hill △1130, three miles north-east of Cumbum and in the hills east of Mirzapeta (57 M/2—15° 37′ 15″:79° 12′ 30″). The limestone outcrop exposed in the hill △ 1130 is slaty and sub-crystalline and can be traced for a short distance only. In the group of hills three miles east of Mirzapeta more than one band of limestone can be seen. In the hill west of ·980 near its south-western end there is a very thin band visible only for a few yards. Here the limestone is light grey and sub-crystalline. On the western flank of hill ·980 there is yet another band about 150 feet wide running parallel to the ridge for a distance of 2 furlongs and dipping 72°, S.E. As in the previous case it is generally light grey in colour but appears rather dark on the weathered surface. But in certain places in the same band it has a pinkish colour with dull green streaks suitable for use as a decorative stone.

Exposures of limestone crop out east of hill ·949 and again 2 furlongs further north-east.

Weathering of Cumbum slate.—The slate outcrops are mostly weathered and iron stained, often assuming drab and brownish grey colour. The black and dark grey slates are the least affected by weathering. The red and purple coloured ones turn to a brown to brownish shade while the greenish chloritic slates become dull greenish in colour. The zone of weathering generally varies from 5 to 10 feet or more, but the prominent cleavage planes are also affected. The surface is often covered with a peculiar calcareous lateritic material, but the quality of the slate definitely improves with depth.

Distribution of slates.—The better quality of slates, including those good enough for the manufacture of school slates, occurring in the Cumbum Slate stage, is confined to a belt about 24 miles in length and 2 miles in width. This belt lies east of Chinna Obanayanipalle (57 M/2—15° 33′ 10″: 79° 11′) and extends north-eastwards passing beyond Tummalacheruvu (57 M/6—15° 39′ 40″: 79° 17′ 20″), Katakampalle (57 M/6—15° 40′ 40″: 79° 18′), Nayudipalle (57 M/6—15° 44′: 79° 19′ 20″), Peddayachavaram (57 M/5—15° 45′ 30″: 79° 40″), Anantavaram (57 M/5—15° 46′ 50″: 79° 22′) villages up to Mallapeta (57 M/5—15° 49′ 10″: 79° 22′ 30″). Only a third of the length of this belt lies within Government territory near Chinna Obanayanipalle, Nayudipalle-Peddayachavaram and Mallapeta; the rest being in the Venkatagiri Zamindari in the Kurnool and Nellore districts. The best slates of the region are, however, confined to the zamindari, but moderately good varieties occur in Government land. In the present investigation attention was paid only to the latter occurrences. The individual bands of the slate are of limited width, rarely exceeding 10 feet. The quality varies from band to band and sometimes even within the same band at short distances along the strike. The quarries are all shallow, mostly within depth of 25 feet but the maximum depth reached is 50 feet. For the purpose of description the slate belt is divided into the following sections: I. Chinna Obanayanipalle belt, II. Nasirsahibpalle-Tummalacheruvu-Katakampalle belt, III. Rayavaram-Mallapeta belt.

I. *Chinna Obanayanipalle belt* (*Shrotriyam lands*).—The slates of this belt are predominantly purplish, mixed with shades of grey. Wherever they crop out at the surface they show dips varying from 60°—85° to the E.S.E. Dips in the opposite direction are also noticed, sometimes within a short distance. Usually the central ridges of the hillocks are composed of quartzites, flanked on either side by slates which appear to dip into the hill from each side thus giving the impression that they form a syncline. This phenomenon, however, is mostly superficial as the dips are deceptive. If the surface material were removed to a depth of a few feet, the true dip is revealed. It is found that the superficial dips towards the central part of the ridge are due to the slumping of the slates during weathering and the consequent tilt.

About one mile east of Chinna Obanayanipalle there is a good band of slate extending for nearly a mile and a half in length passing east of hills 887 (Amada Bodu) and ·702. The maximum width and depth to which quarrying has so far been done are 120 feet and 25 feet respectively. The slates are generally weathered to a depth of 3 feet to 4 feet from the surface but below this the quality improves. There are several quarries within this area yielding good quality slates. Some of them also yield large slabs of size 5 feet×3 feet×1 foot. Sample Nos. 17 to 23 were taken from this band. (See Table on page 560).

Quarrying has been started at the foot of the western flank of hill ·953, one mile S.S.E. of Chinna Obanayanipalle. There are two workable slate bands of which the lower one appears to yield better material and is being quarried at two places. This band measures roughly 700 feet in length and 20 feet in width. The slates have almost vertical or steep dipping cleavage planes (dipping E.S.E.). This makes quarrying easy. The first quarry, located 1 mile 1 furlong 20° E. of Chinna Obanayanipalle, measures 15 feet×8 feet×12 feet. (See Table Sp. No. 13.) The second quarry situated 1 mile S. 25° E. of Chinna Obanayanipalle measures 20 feet×8 feet×15 feet. (See Table Sp. No. 14.)

The upper band, about a furlong in length and 10 feet in width, is separated from the lower by a thin siliceous band about 10 feet wide. As the quality of the slate is inferior and the cleavage not perfect, the quarries in this band have been abandoned. (See Table Sp. Nos. 15 and 16.)

Trial pits near Chinna Obanayanipalle.—To ascertain the nature of slates occurring west of Amada Bodu ·887 and the hill 702 a few trial pits 5 feet or 6 feet deep each, were sunk in the different slate bands which are more or less clearly marked out by the presence of sandy ribbons or thin sandstone intercalations. The trial pits yielded only poor quality slates.

Trial pit No. I.—About ¾ mile E. 30° S. of Chinna Obanayanipalle. Slates fairly hard with irregular cleavage—bluish grey in colour. It is very unlikely that the quality of slates improves in depth.

Trial pit No. II.—About 5 furlongs E. 31° S. of Chinna Obanayanipalle Slates hard with ill-developed cleavage—grey in colour.

Trial pit. No. III.—About 4½ furlongs E. 34° S. of Chinna Obanayanipalle. Slates hard, cleavage ill-developed, colour generally reddish and iron stained.

Trial pit No. IV.—About ½ mile E. 29° S. of Chinna Obanayanipalle. Slates hard with irregular cleavage—light grey colour with a coating of iron oxide.

Trial pit No. V.—About 5 furlongs E. 40° S. of Pedda Obanayanipalle. Cleavage not perfect and colour dark grey. (See Table Sp. No. 24.)

Trial pit No. VI.—About a mile east of Chinna Obanayanipalle. Cleavage irregular, colour purplish.

II. *Nasirsahibpalle—Tummalacheruvu—Katakampalle slate belt.*—The main slate belt producing the best slates lies within the Venkatagiri zamindari. One mile north of Nasirsahibpalle (57 M/6—15° 38′: 79° 16′ 10″) is a band of quartzite intercalation running roughly north-eastwards for several miles passing 1½ miles west of Gajjalakonda (57 M/5—15° 45′ 5″: 79° 23′ 30″). The slate zone east and west of this band of quartzite yields quality slates, the portion of the belt lying between Katakampalle (a shrotriyam village in the zamindari) and west of hill ·908 (two miles S.E. of Markapur railway station) being particularly rich. This area is at present extensively quarried. Between Nasirsahibpalle and Tummalacheruvu and to the east of the quartzite intercalation, there are two trial pits dug by some unknown prospectors. The slates exposed in these pits are grey in colour and dip 80° towards E. 40° S. The cleavage is not perfect enough to yield thin slabs of required thickness for the manufacture of school slates. This portion of the belt does not seem to be promising, from the evidence available.

Slate bands lying on either side of the quartzite intercalation and exposed between Tummalacheruvu and Katakampalle show slates of all grades. West of this quartzite band there is an abandoned quarry measuring 300 feet × 12 feet × 20 feet. The slates in this are purplish and grey, and dip 80° towards E. 40° S. From the dump heaps one could gather that some quantity of material suitable for the preparation of school slates was removed from here. East of the quartzite band no pits are seen. The Tummalacheruvu-Katakampalle area of the slate belt appears to be more promising than the area between Nasirsahib palle-Tummalacheruvu. In the richest portion of the belt lying between Katakampalle and west of hill ·908 there are numerous quarries on either side of the quartzite intercalation. At present good slates are extracted from the eastern flank. The general cleavage strike is N. 30°—40° E.—S. 30°—40° W. with a dip of

80°—85° towards E. 30°—40° S. Opposite dips are also noticed within a short distance across the strike of cleavage. The slates are fairly hard but are variously coloured. The Katakampalle quarries extending for about a mile north-east from the village up to the tank, are 210 feet wide with a maximum depth of 50 feet. They yield grey slates with purplish tint while those west of hill ·908 and worked by the zamindari produce slates of a good dark grey colour. Generally the slates from this area show circular dull red patches and purplish streaks which run more or less concentrically producing a contoured appearance. Sometimes clear dendritic markings are also observed on the split surface of the slates.

It is reported by the quarrymen that the Katakampalle slates, though in most cases purplish in colour, possess perfect cleavage. Most of the factories in Markapur are being supplied from the Katakampalle quarries. The slates are invariably dyed black* before they are put in the market. (See Table, Sp. Nos. 30 and 31.)

In the northern extension of the Katakampalle belt, west of hill ·908 is a quarry measuring 100 feet × 10 feet × 30 feet where the slates are dark-grey in colour. (See Table Sp. No. 32.) The raw slates cut to size are sent to Venkatagiri town where they are framed. These slates need no external colouring and compare favourably with the imported foreign ones. The quarry is being worked on a limited scale and unlike the other areas visited it is noticed that some care is taken to work the quarry systematically.

Further north of hill ·908 there are again good exposures of slates.

As already mentioned, west of the quartzite intercalation between Katakampalle and west of hill ·908, there are several abandoned quarries which formerly yielded good slates for the preparation of school slates. Near the Katakampalle end of the belt the slates are good and dark-grey, but they are definitely harder and yield comparatively thicker slates than those occurring east of the quartzite intercalation. These features are said to make it costlier to work this band.

The slates in this belt are weathered to a depth of less than 3 feet from the surface but in the bed of the tank 1 mile N.E. of

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*The colour of the dye used is black. It is prepared mainly from myrobalam or *terminalia* seeds (*Kadukkai* in Tamil) and ferrous sulphate, which are the common ingredients used for the preparation of indigenous ink. To give some adhesive properties and to deepen the colour jaggery, gum and lamp-black powder are used.

Katakampalle slates are met with below an overburden of 5 to 10 feet. The quarries are still dry although in some places a depth of 50 feet has been reached. The quality of slates is observed to improve at depth. There are abundant reserves of good slates in Nasirsahibpalle-Tummalacheruvu-Katakampalle belt.

Slates from the above belt can also be profitably used as table tops and roofing tiles; also as switch-boards if their electrical resistance is satisfactory.

III. *Rayavaram-Mallapeta belt.*—The slate belt lying between Rayavaram (57 M/6—15° 43′: 79° 18′ 45″) in the south and Mallapeta (57 M/5—15° 49′ 10″: 79° 22′ 30″) in the north passes west of Madulapalle (57 M/5—15° 45′ 5″: 79° 21′) and Anantavaram (57 M/5—15° 46′ 50″: 79° 22′). The slates are generally softer and somewhat inferior to those occurring in the main belt, *i.e.*, Katakampalle belt. They are mostly of purplish and dull-grey colours. sometimes with whitish patches which make them rather unsightly. Cleavage is not very perfect and as a result the slates obtained near Anantavaram and Mallapeta are comparatively thicker than those from the rest of the belt.

Nearly the whole of this belt, except the part about 2 miles long belonging to the Anantavaram shrotriyam village of the zamindari, lies in Government land. Some trial pits (in Government land only) were put down where there were no old quarries available for examination.

Trial pits in the hills ·591 and ·672 near Nayudipalle—Trial pit No. VII.—Three-quarter mile S. 15° E. of Nayudipalle (1¼ miles E. 28° N. of Markapur Road rest-house). Shaly slate with poor cleavage—colour either purplish or reddish—dip 65° E. 30° S.

Old quarry.—Four and a half furlongs S.S.E. of Nayudipalle (1 mile 3 furlongs E. 32° N. of Markapur Road rest-house).

On the eastern flank of the hillock 591 occur one old quarry 50 feet × 20 feet × 15 feet and several trial pits. Slates are generally purplish grey but near the tank (cheruvu) they are dark-grey. (See Table Sp. Nos. 36 and 37). This portion may contain thin bands of good quality for the preparation of school slates.

Trial pit No. VIII.—Three and a half furlongs E. 40° S. of Nayudipalle. Clay slates with ill-developed cleavage—colour purplish—when split come off in rhomboidal pieces as they are badly jointed.

Trial pit No. IX.—Half a mile S. 25° E. of Nayudipalle. Slates weathered and stained red on the surface—splintry and mostly purplish in colour.

Trial pit No. X.—Four and a half furlongs S. 15° E. of Nayudipalle. Slates weathered to a depth of 2 to 3 feet—fairly good cleavage, colour grey with a prominent purplish tinge. (See Table Sp. No. 39.) Slates appear to be good and may improve in depth.

Old quarry.—Three-quarter mile south of Nayudipalle. This old quarry measures 300 feet × 15 feet × 12 feet—20 feet. The slates are generally soft and possess a purplish tint. (See Table Sp. No. 40.) Some bands contain good slates. Between this old quarry and trial pit No. X there is a possibility of meeting with good quality workable slate bands.

Old quarry.—About 1 mile E. 30° N. of Nayudipalle on the eastern flank of hill ·672 there is an old quarry measuring roughly 150 feet×20 feet×12—15 feet; clay-slates are coloured grey to purplish with imperfect cleavage; inferior in quality and mostly quarried for building purposes. Thin bands of quality slates may probably occur in this locality, though the exposed portion did not reveal any.

Trial pit No. XI.—One mile 1 furlong E. 30° N. of Nayudipalle. The slates have fairly good cleavage and are grey in colour. (See Table Sp. No. 42.) Somewhat thick slates are obtained after splitting and this may involve extra labour in the preparation of school slates. It is likely that the quality may improve at depth. This band can be traced for a distance of 240 feet south of the pit and is about 20 feet thick. The chances of getting good slates are promising in this area.

Old trial pits.—One and a half miles E. 30° N. of Nayudipalle. There are several trial pits noticed up to the cheruvu (tank) but the slates exposed are mostly clay-slates with ill-developed cleavage. They are generally greyish in colour.

Trial pit No. XII.—About one and a half miles E. 38° N. of Nayudipalle. Slates generally hard and siliceous with imperfect cleavage. Colour mostly greenish, sometimes bluish and greyish.

Trial pit No. XIII.—One mile one furlong E. 38° N. of Nayudipalle. Slates hard, siliceous with specks of impurities—cleavage ill-developed—colour greenish grey or greyish.

Trial pit No. XIV.—About 7 furlongs E. 30° N. of Nayudipalle. Clay-slates with poor cleavage—colour light-grey with a red coating on the cleavage surfaces.

The general dip of slates on either side of the hills ·591 and ·672 is towards E. 30° S., the amount varying from 50°—75°. The slates generally crop out on the surface and the zone of weathering extends to a couple of feet or more in some places. Although some slates have been extracted, the area has not been properly opened up. The presence of a few bands of good slates is indicated by some of the old quarries and trial pits.

Madulapalle quarries.—Good slates are being quarried by the Standard Furniture Company on the western flank of the hillock to the west of Madulapalle. The quarries extend over a distance of one furlong. The maximum width and depth reached so far are respectively 60 feet and 30 feet. The slates are grey, purplish or greenish and are comparatively softer and possess less perfect cleavage than those of Katakampalle. (See Table Sp. Nos. 46 and 47.) The cleavage dip is 60°, E.S.E. The eastern flank of the hillock was also examined which for the most part is covered over by loose pebbles of quartzite. The few exposures of slates seen are mostly purplish and pinkish in colour. In an old trial pit about 2 furlongs west of Madulapalle the slates are definitely pinkish and do not possess perfect cleavage.

Peddayachavaram quarries.—The hill east of Peddayachavaram, known as the Peddayachavaram hill, extends into the zamindari, the boundary running through the pass. South of Δ 917 in the pass good slates are seen to occur south of this boundary in Government land extending up to the tank east of Peddayachavaram village. The dip of this zone is around 60° to E. 30° S. Slates of different colours are obtained from this area the most common being light-grey; bluish and purplish-grey varieties are also met with. Some of the bands are composed of slates which are soft and light-grey and possess proper spacing of cleavage eminently suited for the manufacture of slate pencils. In fact almost the entire output from Peddayachavaram Konda is used in such manufacture. The thickness of these slate bands vary from few inches to few feet and their distribution is limited to a small area only. The material from some bands is used also for making school slates. Since the slates from this hill are grey they are not usually dyed black. (See Table Sp. Nos. 49 to 54.)

Along the whole length of the western flank of the hill extend numerous old pits and quarries, the working one being very near the boundary of the zamindari. This quarry measures roughly 300 feet × 60 feet × 40 feet. The good workable slate bands are usually never more than a few feet in thickness; the quality varies from band to band and sometimes within the same band, but the reserves of slate are abundant.

On the eastern flank of Peddayachavaram hill about 7 furlongs N. 5° E. of Madulapalle is an old trial pit where the exposed slates are not good enough for the manufacture of school slates or pencils. (See Table Sp. No. 55.)

Anantavaram quarries.—The Peddayachavaram band continues north-eastwards into the Anantavaram hill Δ 917 in which the quality becomes definitely poorer. This change in quality is rather abrupt just beyond the Government area and the slates are soft and pinkish to purplish in colour. (See Table Sp. No. 56.)

North of Δ 917 about 1 mile W. 30° S. of Anantavaram there are quarries extending for more than 2 furlongs. It is reported that these were the earliest to be opened in this belt. Although there are still some workable bands most of these quarries are now closed down. Running parallel to the abandoned quarries, at the foot of the hill on its western flank are some working quarries. The slates dip at 45° towards E. 40° S. Their approximate total length is 300 feet and width 20 feet. The slates show various shades of grey, mostly light grey, with often a dull purplish tint and occasional white patches. They are softer than those in the Katakampalle area and the cleavage is not so perfect. Unworked bands of hard slate which are unfit for the preparation of school slates can however be utilized for making table tops or as building materials. (See Table Sp. Nos. 57 and 57-A.)

In the Peddayachavaram and Anantavaram areas good slates are generally obtained near the surface but sometimes an overburden 5—10 feet depth has to be removed to strike good bands of slates.

A new quarry has been started recently 2 furlongs north-east of the above quarries north of the Anantavaram-Peddayachavaram footpath (5 furlongs W.S.W. of Anantavaram). It measures 150 feet × 30 feet × 15 feet and yields good slate with grey colour, sometimes with a pinkish tinge. The dip of the slate is 45° towards E. 40° S. (See Table Sp. No. 58.)

Situated in the same belt about 3 furlongs N. 35° W. of Anantavaram, and extending for nearly a furlong, are other quarries most of which were abandoned for several years. A quarry which has restarted working measures 300 feet × 50 feet × 15 feet. The slates are greyish, greenish or purplish (see Table Sp. No. 59). The dip is as low as 35°—40° towards E. 40° S. East of this quarry there is a possibility of striking good slate bands as there are good indications in some of the old trial pits.

The quarries from which specimens 56 to 59 were taken belong to the Anantavaram shrotriyam village in the Venkatagiri zamindari. The slate reserves in the Anantavaram belt are fairly large.

Mallapeta quarries.—The north-easterly continuation of this belt contains workable slate bands near Mallapeta. Mr. B. V. Joshi who works the Peddayachavaram hill quarries tried a few trial pits one and a quarter mile south of Mallapeta. The slates exposed in these pits are soft and dull grey in colour with often white patches. A quarry is being worked here whose dimensions are 240 feet × 25 feet × 15 feet (see Table Sp. No. 60).

Trial pits in the area south of Mallapeta.—A few trial pits were put down in this area to depths varying from 4—7 feet. They are described below:—

Trial pit No. XV.—One and a half miles south of Mallapeta—depth 4 feet. Slates slightly warped with irregular cleavage, colour dull grey, bands of siliceous slates also occur.

Trial pit No. XVI.—One and a quarter miles S. 5° E. of Mallapeta—depth 7 feet. Slates obtained in large slabs 2 feet square and not less than ½ inch thick—colour dark grey (see Table Sp. No. 63).

Trial pit No. XVII.—One mile 1 furlong S. 8° E. of Mallapeta—depth 5 feet. Slates with good cleavage—colour purplish. It is possible that the quality may improve at depth.

Trial pit No. XVIII.—About one mile S. by E. of Mallapeta—depth 4½ feet. Slates with imperfect cleavage and dull pinkish grey colour.

Trial pit No. XIX.—One mile S. 6° E. of Mallapeta—depth 6 feet. less than ½ inch thick. (See Table Sp. No. 66.)

The trial pits do not reveal the presence of very good quality slates in this area. However, the slates exposed in trial pits XVI, XVII and XIX are fair and can be utilized. The eastern side of the slate belt is limited by a bed of quartzite. The reserves of good slates in this area are limited.

East of this quartzite and between Anantavaram and Gajjalakonda there are three or four well marked quartzite beds alternating with slate bands. These slates are however not good enough for the manufacture of school slates, but can be used as building materials, such as paving slabs, etc.

QUALITY OF MARKAPUR SLATE

As already mentioned, good slates have a limited distribution and are restricted to a belt extending from Anantavaram through Katakampalle to Obanayanipalle. The north-eastern part of this belt, from Anantavaram to near Nayudipalle contains somewhat inferior material than the main belt passing through Katakampalle. The slates of the main belt are generally harder and darker than those of the subsidiary one and are therefore more in demand. The colours met with are dark grey, greenish grey and pinkish grey to pink.

Six pieces from the collections made at various places were sawn and used for the absorption test. They were dried at 105°—110° for about 8 hours, cooled to room temperature and kept immersed in a basin of water for 38 to 40 hours. The quantity of water absorbed, expressed as percentage of the weight of the respective piece tested, varied from 0·2 to 0·5 per cent. The number of pieces tested were not enough to establish any special relationship between the appearance and absorption. At any rate, the absorption is in general satisfactorily low, and compares well with that of good slates of other countries.

ELECTRICAL RESISTANCE

A number of representative specimens taken from the exposures and test pits in the slate belt, leaving out those which were not of tolerably fair quality, were prepared carefully into rectangular slabs of uniform thickness and sent for testing to the Principal, College of Engineering, Guindy near Madras.

The results of the tests are given in the following table. Those in which the insulation resistance found by experiment is higher than that of the minimum resistance according to the specification are marked 'good' and the others 'poor'.

It will be seen that only 13 of the 37 specimens submitted to the tests are good and can be used for switchboards. The specimens which have passed the test are all generally grey, though some are tinged with other colours and may contain specks or patches. The presence of graphitic matter and of iron oxides in the slates will disqualify them for insulation purposes, but compact, homogeneous, serictic material will prove useful.

In recent years, however, other insulating materials have been developed which are more satisfactory than slate, *e.g.*, porcelain, steatite and certain materials including synthetic ones. It is therefore doubtful whether these slates will be used for electrical purposes to any appreciable extent.

Table of test results on slate slabs from Markapur

Serial number of the slab.	Description.	Thickness in inches.	Insulation resistance as found by tests.	Min. ins. resist. required by Spec.	Remarks.
			Megohms		
13	Light grey with purple patches and layers.	3/8	0·17	0·3	Poor.
14	Grey with pink streaks	5/16	0·16	0·25	Do.
15	Grey with greenish tinge	1/4	0·31	0·2	Good.
16	Black (dark)	1/2	0·31	0·35	Poor.
17	Light purple	3/8	0·31	3	Good.
18	Purple grey with greenish tint . . .	3/16	0·33	0·15	Do.
19	Purplish grey with small reddish brown streaks.	3/8	0·16	0·3	Poor.
20	Light greenish grey	3/8	0·16	0·3	Do.
21	Grey with purple tinge	5/16	0·50	0·25	Good.
22	Grey with light purple patches . . .	3/16	0·26	0·15	Do.
23	Do. . . .	1/4	0·31	0·2	Do.

Serial number of the slab.	Description.	Thickness in inches.	Insulation resistance as found by tests.	Min. ins. resist. required by Spec.	Remarks.
			Megohms.		
24	Dark grey	1/2	0·11	0·35	Poor.
30	Pinkish grey with purple patches	7/16	0·12	0·32	Do.
31	Grey (slightly pinkish)	1/4	0·23	0·2	Good.
32	Light pinkish grey	5/16	0·36	0·25	Do.
36	Light grey	3/8	0·093	0·3	Poor.
37	Dark (slate) grey	9/16	0·15	0·37	Do.
39	Purplish grey with light grey patches	3/8	0·50	0·3	Good.
40	Light purple grey	3/8	0·11	0·3	Poor.
42	Grey with whitish layers	5/16	0·10	0·25	Do.
46	Grey	3/8	0·05	0·3	Do.
47	Grey with minute dots	3/16	0·17	0·15	Good.
49	Purplish with dark grey layers	5/16	0·15	0·25	Poor.
50	Grey	1/2	0·33	0·35	Do.
51	Do.	3/4	0·35	0·43	Do.
52	Do.	3/16	0·31	0·15	Good.
53	Light grey with purple layers	5/16	0·066	0·25	Poor.
54	Grey	3/16	0·5	0·15	Good.
55	Grey with purple layers	9/16	0·092	0·37	Poor.
56	Light grey with pinkish layers	9/16	0·17	0·37	Do.
57	Light grey with pink streaks and whitish layers.	5/16	0·06	0·25	Do.
57A	Light grey with purplish layers	7/16	0·062	0·32	Do.
58	Grey	3/8	0·16	0·3	Do.
59	Light grey with white specks	5/16	0·42	0·25	Good.
60	Dark grey with purplish layers and white specks on the surface.	7/16	0·20	0·32	Poor.
63	Dark grey with whitish patches	3/8	0·15	0·30	Do.
66	Light purplish grey	9/16	0·17	0·37	Do.

Temperature: 25°C. Humidity: 78 per cent.

Specimen number.	Locality.
13	One mile 1 furlong S. 20° E. of Chinnaobanayanipalle.
14	One mile S. 25° E. of Chinnaobanayanipalle.
15	One and a half furlongs east of specimen No. 13.
16	About 1 mile E. 54° S. of Chinnaobanayanipalle.
17	Two furlongs S. of hill ·887 (Amada Bodu).
18	One furlong S.S.E. of hill 887 (Amada Bodu).
19	Half a furlong east of hill 887 (Amada Bodu).
20	Two furlongs N.E. of hill ·887 (Amada Bodu).
21	Half a mile N.E. of hill ·887 (Amada Bodu).
22	Eastern flank, east of hill 702 (1¼ miles E.N.E. of Chinnaobanayanipalle).
23	About 100 yards north of Specimen No. 22.
24	About 5 furlongs E. 40° S. of Peddaobanayanipalle.
30	North-east of Katakampalle.
31	One mile N.E. of Katakampalle.
32	About 2 miles E. 60 S. of Markapur Road Railway Station.
36	Half a furlong east of above locality.
37	Do.
39	Four and a half furlongs S. 15° E. of Nayudipalle.
40	About ¾ mile south of Nayudipalle.
42	One mile one furlong E. 30° N. of Nayudipalle.
46	About 1½ miles E. 28° N. of Mannemvaripalle.
47	About 3 furlongs west of Madulapalle.
49	About 1¼ miles east of Peddayachavaram.
50	One mile 3 furlongs E. 18° N. of Peddayachavaram.
51	About 100 yards E.N.E. of Specimen No. 50.
52	Hundred yards N.E. of Specimen No. 51.
53	One and three-fourth miles E.N E. of Peddayachavaram (slate pencils).
54	One and three-fourth miles E.N.E. of Peddayachavaram (slates).
55	Seven furlongs N. 5° E. of Madulapalle.
56	Half a furlong north of Specimen No. 53.
57	About 7 furlongs W. 30° S. of Anantavaram.
57A	Hundred yards south of Specimen No. 57.
58	About 5 furlongs W.S.W. of Anantavaram.
59	Three furlongs N. 35° W. of Anantavaram.
60	About 1¼ miles S. 5° E. of Mallapeta.
63	Fifty yards south of the above locality (60).
66	One mile south of Mallapeta.

CONCLUSION

The only implements used in quarrying are crowbars, spades and hammers. The quarrying is done by men of the stone mason class and lacks method. After the overburden is removed, crowbars are used for prying out the slate blocks. During this process there is much wastage due to breakage and only those slabs which are over 1 inch in thickness and more than a foot in length and breadth are taken out for use. Thus most of the material, which generally forms 90 per cent. of the total is dumped along the edge of the quarry or left in the quarry itself. At least some of the waste material can be put to use such as filler, paint material, aggregate for concrete, etc. The quarries are abandoned after reaching about 20-25 feet depth generally because the quarrying beyond that depth becomes more difficult and costly.

The slate blocks are removed in bullock carts to Markapur town where the 'factories' are situated. Splitting is done by means of thin wedges and the resultant slabs are planed by hand by means of small steel straight-edges. The school slates thus produced are not quite plane-surfaced in spite of the labour expended on them.

During the splitting and thinning operations which are all done by hand, about 50 to 60 per cent. of the slate slabs are spoilt and thrown away. Thus barely 5 per cent. of the slate in the quarry (and sometimes even less) emerges finally as a marketable product.

No effort seems to have been made by the concerns to prepare the slate for roofing or paving. A certain amount of quarry waste is of course used to make boundary walls and to build the walls of the huts of the poor people but it is merely because this material is handy and costs nothing to collect. In rare instances, the yield of some quarries which were not suitable for making school slates were trimmed to a uniform square or rectangular shape and sent to neighbouring towns as paving stones in houses. Though there are some 30 to 40 'factories' at Markapur, only one or two were using anything which could be called mechanical aids in the preparation of the slate for planing or trimming. The competition is keen and the wage levels are low. Some 2,000 people are said to be engaged in this industry.

In order to be able to put on the market products with proper finish, it is necessary that the factories be equipped with circular stone-cutting saws for shaping the blocks, guillotine machines for trimming, and rubbing bed or similar device for planing

These will eliminate much manual labour, save a lot of wastage and ensure the output of a much better and uniform quality of the product. Not only could school slates be prepared properly, but also a large proportion of the present quarry waste could be shaped as roofing and flooring tiles of uniform size and shape.

There is a small slate pencil factory near the railway station. It utilises a grey soft slate from near Peddayachavaram. The slate slabs are first split to a thickness of about a quarter of an inch and cut into thin long strips along the grain by feeding them into a machine consisting of a cylinder revolving on a horizontal axis, the cylinder having closely spaced sharp ridges which cut into the slate during revolution. Several of these cylinders are attached to the main shaft driven by an oil engine. The strips are rounded by hand, cut into 5-inch lengths and packed for export. The factory is a very small one producing only a few thousand pencils per day. The soft slate of certain areas is eminently suited for pencil manufacture and the output of pencils can be greatly expanded, especially if use can be made of much of the waste matter of some of the quarries.

It will be seen that there is much scope for improvement in all the aspects of the industry—quarrying, preparation and marketing—which can be effected by Government providing technical advice to the lessees and owners of the slate factories and ensuring that such advice is followed.

ACKNOWLEDGMENTS

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INDEX TO SOME IMPORTANT LOCALITIES.

Locality.	Sheet number.	Latitude.	Longitude.
Anantavaram	57 M/5	15 46′ 30″	79° 22′
Bestavarapeta	57 M/2	15° 33′	79° 6
Chinna Obanayanipalle	57 M/2	15° 33′ 10′	79° 11′
Cumbum	57 M/2	15° 34′ 30″	79 6′ 0′
Gajjalakonda	57 M/5	15° 45 5″	79° 23′ 30″
Katakampalle	57 M/6	15° 40′ 40″	79° 18′
Lanjakota	57 M/2	15° 36 20″	79 10 50″
Madalapalle	57 M/5	15 45′ 5′	79° 21′
Mallapeta	57 M/5	15° 49 10″	79 22′ 30″
Mannemvaripalle	57 M/6	15 44′ 20″	79° 19 35″
Markapur	57 M/6	15 44′	79° 16 30″
Markapur Road Rest House	57 M/6	15° 42′ 50″	79 18 20″
Markapur Road Railway Station	57 M/6	15 42′ 50″	79° 18′ 20″
Mirzapeta	57 M/2	15° 37′ 15″	79° 12′ 30″
Motupalle	57 M/2	15° 35′ 50″	79° 11′ 25″
Nadimpalle	57 M/2	15° 36′	79° 8′ 45″
Nasirsahibpalle	57 M/6	15° 38′	79° 16′ 10′
Nayudipalle	57 M/6	15° 44′	79° 19′ 20′
Peddaobanayanipalle	57 M/2	15° 34′ 10″	79° 11′ 40″
Peddayachavaram	57 M/5	15° 45′ 30″	79° 19′ 40″
Rayavaram	57 M/6	15° 43′	79° 18′ 45″
Tummalacheruvu	57 M/6	15° 39′ 40″	79° 17′ 20″

LIST OF REFERENCES

BALASUNDARAM, M. S. and JACOB, K. (1945).—Report on the slates of Cumbum and Markapur, Kurnool district. *Govt. Madras, Dev. Dept.*, G. O. No. 2147.

BEHRE, C. H. JR. (1928).—Geologic factors in the development of the Eastern Pennsylvania slate belt. *Trans. Amer. Inst. Min. Eng.*, 76, pp. 393-412.

BEHRE, C. H. JR. (1933).—Slate in Pennsylvania *Penn. Geol. Surv. Bull.*, M-16.

BOWLES, O. (1922).—The Technology of slate. *U. S. Bur. Mines. Bull.*, 218.

BOWLES, O. (1924).—Technical progress in slate mining. *Eng. Min. Journ.*, 117, p. 606.

BOWLES, O. (1926).—Recent Progress in slate technology. *U. S. Bur. Mines. Rept. Invest.*, No. 2766.

BOWLES, O. (1930).—The wire-saw in slate quarrying. *U. S. Bur. Mines. Techn. Paper*, 469.

DALE, T. N. (1914).—Slate in the United States. *U. S. Geol. Surv. Bull.*, 586.

ECKEL, E. C. (1912).—Building stones and clays. *New York.*

GOLDMAN, M. I. and MERWIN, H. E. (1928).—Colour chart for the description of sedimentary rocks. *Nat. Res. Council, Washington.*

JANNETAZ, E. (1884).—*Bull. Soc. Geol. France*, Vol. XII.

KRISHNAN, M. S. (1941).—Report on slate near Markapur, Kurnool and Nellore districts, Madras Presidency. *Govt. Madras, Dev. Dept.*, G. O No. 1024.

LEITH, C. K. (1905).—*Rock cleavage. U. S. Geol. Surv. Bull.*, 239.

ILMENITE AND GARNET SANDS OF THE CHOWGHAT (WEST COAST), TINNEVELLY, RAMNAD AND TANJORE COASTS (EAST COAST)*.

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* Based on report submitted in 1943 and published by Govt. of Madras, *Development Department* as G. O. No. 3088, dated the 15th July 1944

The present paper embodies the results of the investigation carried out during the field season 1942-43 by the author under the supervision of Dr. M. S Krishnan, then Geologist-in-Charge, Southern Circle, on the ilmenite deposits of the Chowghat-Ponnani coast and of the coasts of the Tinnevelly, Ramnad and Tanjore districts.

I express my sincere gratitude to Dr Krishnan for his valuable help and guidance ungrudgingly given both in the field and in the preparation of this report.

I. ILMENITE SAND

Ilmenite is fairly widely distributed along the coasts, but it is only in some places that the concentration is of sufficient richness to be called ilmenite sands.

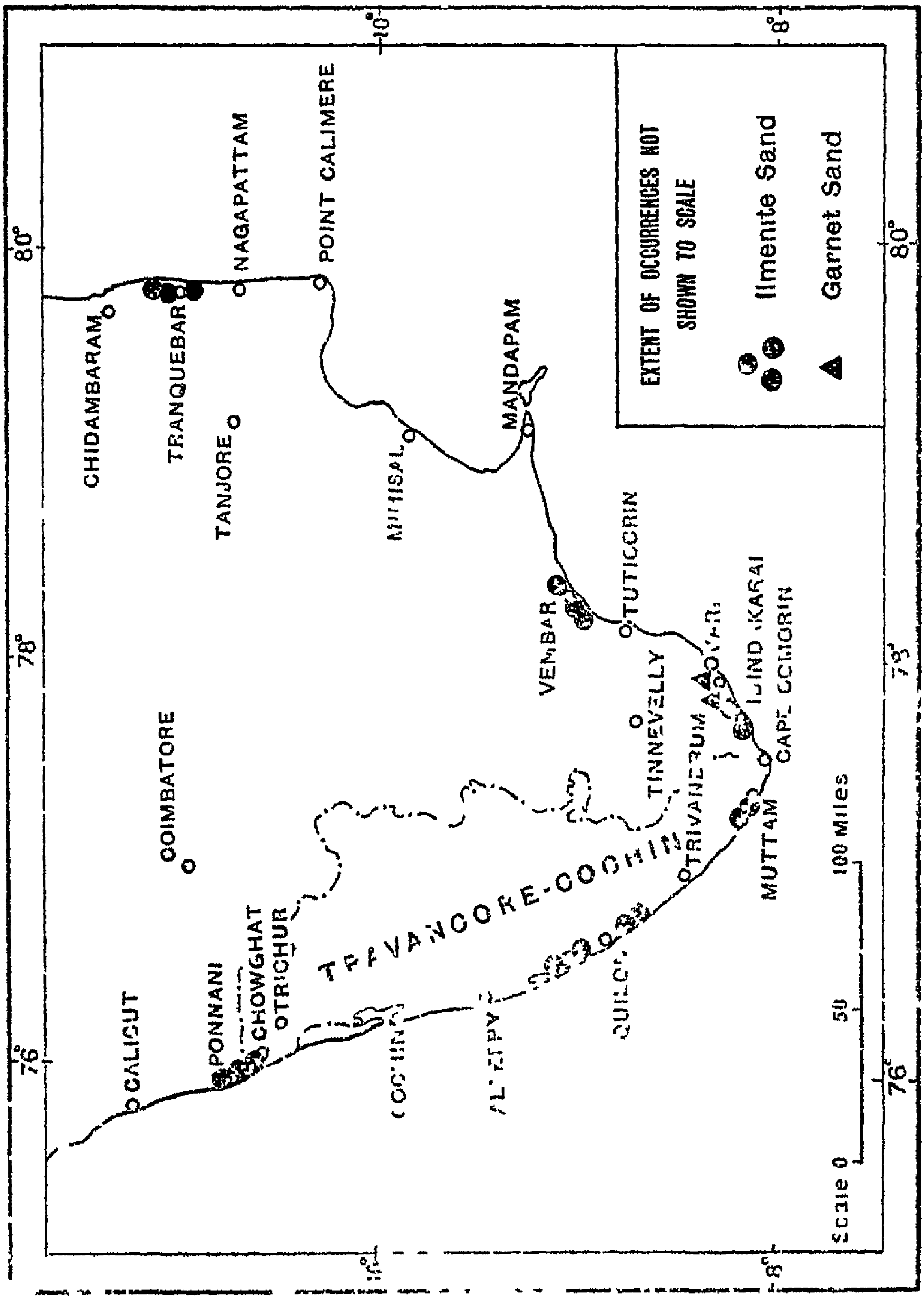
These deposits are not comparable in extent and richness to those found in the Travancore State. Of the four districts visited by the author, the best deposits are to be found along the Chowghat-Ponnani coast (Malabar district). Other patches of ilmenite sands occur associated with the mouths of the Vaipnar and the Kallar in the Tinnevelly district and near Tranquebar in the Tanjore district. Besides the above, several smaller patches of fairly good concentration of very limited extent are met with along the eastern coast.

1. *Distribution*

Coastal sands.—The deposits are usually found along the shore associated with the streams or rivers and occur either directly at their mouths, or transferred to some distance along the shore, depending on the direction of the prevailing current. It is only in the case of the smaller streams that the deposits are found more or less directly associated with their mouths. On the other hand the greater proportion of sediments brought down by the larger rivers is carried away to some distance into the sea by the force of their currents. The heavy sands may be returned to the shore some considerable distance away from the mouth, depending on the ocean currents.

The deposits are often caught up in the small bays. Frequently the limits of the ilmenite patches are sharply demarcated by streams or small promontories.

On the West Coast in the Chowghat-Ponnani area, the ilmenite deposits occur between the Chettuvayi and the Ponnani rivers. There are hardly any noticeable bays or promontories in this short strip of the shore. On the Travancore coast many of the rivers empty into the sluggish backwaters from where the heavy minerals probably find their way on to the sea. In Ceylon, too, large quantities of black sands, locally known as "*nambu*",



occur at the mouths of rivers, particularly of the Kelani Ganga and the Maha and Gin Oyas (Johnstone, 1916).

Tipper (1914) in his observations on the monazite deposits of the Travancore coast concludes that, with one exception, the deposits described by him are not apparently associated with any large streams. He finds it difficult to see how the heavy minerals washed out of the rocks can reach the sea in large quantities; for they empty themselves into the backwaters. Chacko (1917), however, differs from him and points out that the heavy particles do travel and find their way to the bars. Particularly in South Travancore the monazite deposits are seen associated with the smaller streams. Along the East Coast also, as pointed out above, many of the deposits are seen more or less immediately connected with the smaller rather than the larger streams.

Dry beds of streams.—Concentrates of the sands are occasionally found in the dry beds of some of the streams which usually contain water immediately after heavy rains. Sands of noticeable concentration are not met with in the larger rivers. Even in the case of the smaller streams, it is chiefly in those that flow through the *teri* country in South Tinnevelly that the heavy sands of sufficient concentration are seen. Near Vijayapati where smaller streams flow through country composed of disintegrating crystalline rocks, good concentrates in small quantities are noticeable.

White or younger dunes.—Traces of ilmenite, monazite, zircon and garnet are usually found in these dunes which are formed from the material blown from the shore. At some places due to the sorting action of winds there is a thin surface concentration of ilmenite which imparts a deep grey colour to the dunes. The lighter minerals slip down the sides of the dune leaving the ilmenite and other heavy grains on the sloping surface. Sometimes the place of ilmenite is taken by garnet when the dune assumes a dull pink tinge.

Red teris or older dunes.—The *teris* or red dunes lie some distance away from the shore and form a characteristic feature of the Tinnevelly and parts of the Ramnad districts. So far as I have seen, this feature is absent in the Malabar and Tanjore districts. The dunes are predominantly of a red colour due partly to the decomposition of iron-bearing minerals and partly to the presence of a fine red clay. The proportion of the heavy minerals which they contain seems to be greater than what occurs in the white coastal dunes. In particular, in the beds of the rivulets flowing through the *teri* country, as already mentioned above, some quantity of the black concentrates could be collected.

Older dunes of a bright red colour are reported to be present at the Cape Comorin and at Muttam in the Travancore State. Here too, as reported by Tipper (1914) and Chacko (1917) there is a higher proportion of the heavy minerals than in the case of the white or the younger dunes in those regions.

Tank beds.—It has been noticed that in many of the tanks into which small rivulets empty the rain waters from the area of the red dunes, fairly good concentrates of black sands occur. The bed of Kadamba Kulam is reported to contain a good concentration of ilmenite. At the time of my visit, however, the tank was overflowing owing to heavy rains and the reported occurrence could not be examined.

2. *General characters of the deposits*

Although many of the deposits have their own peculiarities they present some common features.

They are usually black or steel-blue in colour due to the high percentage of ilmenite. The sands may assume a pink tint when rich in garnets.

The deposits vary in depth from a thin film to a foot or more in thickness. Often they are inter-bedded with layers of white sands of varying thickness. The width of the belt of concentrates varies from a foot to several yards. The best concentrates is usually found between the high and low water marks, where the sorting action of the waves is in progress at the time. At the high water mark a small ridge is generally formed which exposes a few bands of concentrates.

In some places the deposits extend further landwards some yards beyond the high watermark. On the East Coast right at the mouth of some of the smaller streams bands of concentrates are exposed on either bank.

Near Veppalodai the sands are seen consolidated into a fairly cohesive rock with one or two bands of ilmenite of good percentage.

The concentration of ilmenite and other heavy minerals in the bands of black sands is variable from place to place and often from band to band at the same place, as will be seen from the results of separation. There is always a high percentage of ilmenite in these sands ; the proportion of magnetite is generally low probably because it is less stable than ilmenite, or because it is less common in the country rock from which the heavy minerals have been derived.

If the sands on the East and West Coasts are compared, it is found that the deposits on the Chowghat coast contain, on an average, a higher percentage of magnetite and generally less of garnet than those on the East Coast. There is a higher percentage of epidote in the black concentrates of the Chowghat-Ponnani coast. The garnets are in greater abundance in southern Tinnevelly than elsewhere on the East Coast. In some localities they occur in sufficient concentration to form deposits of garnet sands. These occurrences are treated in a separate section. For details of the minerals and their approximate percentage on the West and East coasts, reference may be made below.

An examination of the different areas reveals that the heavy minerals in the sands are concentrated in their finer grades, because, for a certain dominant size of quartz and other lighter minerals, there is a smaller size of ilmenite and other heavy minerals which are deposited together as they have the same settling rates. This fact is made use of in the case of some of the samples to achieve a preliminary separation by screening before using the electro-magnet.

3. *Seasonal variation in deposits*

At some places the ilmenite sands appear at certain times and disappear afterwards. I had occasion to visit the Chowghat-Ponnani area, once during November-December 1942, and again in August-September 1943. The second visit took place immediately after the south-west monsoon. It was noticed that two or three minor deposits not observed during the first visit were seen to occur at certain localities on the coast north of Blangad, between the high and the low watermarks. On the other hand parts of certain other surface deposits noticed during the first visit were seen to be covered over by a layer of white sands. I was told that in some places on the East Coast, like Idindakarai and Kuttankuli the deposits extend for a longer stretch of the coast during, and immediately after, the north-east monsoon. Thus it would appear that some of the deposits are not permanent and changes take place particularly during the south-west monsoon on the West and the north-east monsoon on the East Coasts. Such changes taking place during one season may be usually insignificant.

In his observations on the Travancore deposits Chacko (1917) concludes that the sands are found more concentrated and in more places during the south-west monsoon.

The causes that bring about such changes may be attributed to a combination of several factors, such as the violent action of the waves during the monsoons, the drift of the prevailing current and the flooded nature of the rivers and streams which carry a larger proportion of debris from inland areas during the monsoons. These sediments will be carried further away into the sea by the more forceful flow and to longer distance along the shore by the oceanic currents and finally thrown up and concentrated by the more violent monsoon waves at spots which previously showed no noticeably black concentrates. It has also been observed that during the monsoon the waves advance a greater distance inland than during the quiescent period and thus may reach some deposits of poorer concentration which are improved by the sorting action of the waves, giving the impression of a newly formed deposit. Due to the same reason, as observed on the Chowghat-Ponnani coast, parts of the shore where ilmenite deposits occur, assume a more sombre colour between the high and the low watermarks during the monsoon. I had no opportunity to examine any of the East Coast deposits either during, or immediately after, the north-east monsoon. But I was informed that along the shore where ilmenite deposits do occur the stretch of the coast assumes a darker colour during the monsoon.

Tipper (1914) believes that it is during the quiescent period that the sorting action of the waves is at its best and actual concentration proceeds at a rapid rate. He assumes that during the south-west monsoon on the Travancore coast ordinary beach material will be heaped up along the coast. This does not appear to be quite in accordance with the observed facts on the Chowghat-Ponnani coast.

4. *Minerals*

Several minerals have been identified in the samples collected from the different areas. In general, besides ilmenite, magnetite and garnet, smaller percentages of monazite, zircon, rutile, epidote, sillimanite, quartz and a few others such as hæmatite, limonite and felspar may be recognised. It is considered advisable to describe in brief the various minerals recognized in the samples collected from the West and the East Coasts. Only characters of particular interest are mentioned in the subsequent paragraphs. Except in the case of magnetite and ilmenite the percentages of the other minerals were computed by counting the grains in mixtures. The figures are given as a rough estimate.

Magnetite.—The grains are generally worn often showing angularities with a dull metallic lustre and black colour. No clear crystalline form is seen preserved; strongly magnetic;

inclusions absent; fracture somewhat conchoidal and uneven. Some of the few grains of haematite and limonite seen in certain samples are probably derived from the magnetite. Titaniferous magnetite may also be present.

The *percentage* of magnetite in the sands on the West Coast varies from 3 to 18; on the East Coast from 1 to 11. Except for the Tranquebar deposits where the percentage may be as high as 20, it is generally low on the East Coast.

Ilmenite.—The grains are variable in size and are generally much worn and well rounded in many cases; others are somewhat flaky with slight angularities; black, with a metallic lustre and bright sheen; moderately magnetic. In the samples examined no coating of leucoxene has been observed.

Percentage.—The heavy sands of the Chowghat-Ponnani coast contain 33 to 67 per cent., may be still higher in some bands. An average sample gave the value of 49 per cent. On the East Coast the percentage varies from 34 to 85 per cent. In some dry stream beds near Kuttankuli, the percentage is as high as 91. The mineral forms the highest proportion in these black sands.

Monazite.—The grains are usually small. Two varieties exhibiting two distinct colours, one yellowish brown and the other greenish yellow,[*] are met with on the Chowghat-Ponnani coast. The grains are much worn, very rarely fractured, egg-shaped or even rounded; resinous to translucent; weakly magnetic.

The percentage apparently varies from a trace to 2 or at the most 3.

On the East Coast the greenish yellow variety[*] has not been observed so far. A short distance away from the coast behind the row of dunes near Vijayapati, monazite grains are found to be of larger size. The *percentage* of this mineral in this locality is less than 4. This area requires careful prospecting.

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[*] This is probably Bowie and Horne's (1953) new mineral of the monazite group, *Cheralite.* However, the mineral occurring as grains in the beach sands on the Chowghat Coast, was observed by the present author as early as 1943 to be distinct from the common yellowish brown variety (see Jacob, 1944). Wadia's (1952) *Travancorite* briefly mentioned by him without giving the optical properties and detailed chemical analysis, is probably the same mineral. But the new name *Cheralite* under which the mineral was fully described will be recognised by mineralogists.

Zircon.—The grains are colourless, transparent, adamantine, occasionally exhibiting zoning. Fracture common, conchoidal. Doubly terminated as well as rounded grains are met with; non-magnetic.

Percentage.—Without achieving a clean separation of the mineral by the use of heavy liquids it is impossible to give the correct idea of the percentage of zircon. But it appears that it is near about 5. The percentage may be slightly higher on the East Coast.

Garnet.—The grains of garnet occurring in the ilmenite sands are generally small. Some of them are deep pink, others are of lighter colour. They usually occur in the sands as highly fractured grains without any recognizable crystal form; vitreous lustre; weakly magnetic. It appears that there are at least two types of garnet present in the Chowghat sands, one of them being the common almandine.

Percentage.—The ilmenite sands on the West Coast probably contain not more than 20 per cent. of garnet. The garnet sands of the East Coast. considered separately elsewhere show a higher percentage.

Rutile.—The grains are reddish-brown in colour; euhedral and terminated grains are both present. fracture sub-conchoidal, lustre adamantine; non-magnetic.

Percentage.—It appears from a cursory examination of certain micro-slides prepared from samples of the sands that the percentage is very low, probably less than 1 per cent. It is apparently lower in the East Coast deposits.

Hypersthene.—Only a few grains are met with in some of the preparations. They are pale pink and green in colour, markedly pleochroic and occur as worn, elongate cleavage fragments; weakly magnetic.

The *percentage* is very low in the sands. The mineral is probably present in the East Coast deposits as well, but so far it has not been observed in the slides examined.

Sillimanite.—Somewhat elongate with a suggestion of a bluish tinge of colour; cleavage well marked, non-magnetic.

Percentage very low, less than 1.

Amphibole.—A few grains are seen in the preparations; light greenish brown, more or less elongate, cleavage present, weakly magnetic.

Percentage very low, less than 1

From the sands near Tranquebar, besides the above, another variety of a bluish green colour is also observed. The grains are somewhat rounded and translucent.

Titaniferous augite.—Seen so far only in the sands near Tranquebar; pale brownish gray in colour, poorly rounded, pleochroic.

(?) *Ceylonite.*—A greenish black mineral, very weakly magnetic, with conchoidal fracture is found in the Tranquebar sands. It may probably belong to the species ceylonite.

Quartz.—Grains are usually sharply angular, colourless with a smooth dull surface. The percentage of quartz on the East and the West coasts is not very different.

Shell particles.—Generally between the high and low watermarks, hardly any shell pieces occur in the heavy sands. But beyond the high watermark, a few pieces are generally met with.

Hæmatite and felspar also occur in the heavy sands both on the East as well as on the West Coasts.

5 *Sources of the heavy minerals*

Attention was almost entirely devoted to the examination of the coastal sands, as such, there was no opportunity to investigate the rocks in the interior in order to obtain an insight as to the origin of the heavy minerals.

East Coast.—It is surmised that the heavy mineral suites of the East Coast have as their primary source the granitic gneisses and, particularly in southern Tinnevelly, the garnetiferous gneisses resembling leptynites. The latter, as mentioned by Chacko (1917) in the case of such rocks in Travancore, has quartz, felspar and garnet as its essential constituents, with monazite, ilmenite or magnetite as accessory minerals. Holland (1910) makes the observation that ilmenite is a common constituent of the peninsular charnockites and pyroxene granulites.

Another and quite a fertile and immediate source of the heavy sands is the red *teris* or dunes lying a little away from the coast. The distribution and probable origin of these dunes have already been briefly mentioned. The small streams that drain these dunes after heavy showers, show a concentration of the heavy minerals in their dry beds. The stream near Kuttankuli from where samples of ilmenite sands of good percentage could be collected, derives the minerals directly from the red *teris* which occupy extensive areas in these regions. Wherever such dunes exist they form a good source of the heavy minerals. Some of these streams, as already mentioned, drain into inland tanks where, it is reported, black sands of good percentage occur.

Chacko (1917), in discussing the source of the Travancore monazite, mentions the pegmatites and leptynites as the primary source, with the "Warkali beds or teri" forming the "secondary source". The disintegration products of the crystalline rocks are stored in the Warkali beds which, after easy disintegration, contribute most of the monazite deposits. The sources of East Coast deposits are not apparently very different in nature.

The deposits near Tranquebar are probably derived entirely from the crystalline rocks, the minerals being brought down by the Cauvery and its branches. There are no dunes like the red *teris* of Tinnevelly contributing their share.

West Coast.—It is believed that the heavy minerals on the Chowghat-Ponnani coast are derived from the charnockites, the nearest exposure of which is found about 3 miles east of the coast near Arthab.

6. *Prospecting*

Test pits of average dimension of 2½ feet diameter and about 4½ to 5 feet depth were dug at measured distances in all the areas where patches of heavy black sands were observed, to enable the computation of the probable lateral and vertical extensions of these deposits. The distances between the pits were governed by local conditions. Beyond 5 feet depth there is usually seepage of water, the sides of the pits gradually falling in.

The calculation of the total mineral content in any area was made by joining on a rough plan every four adjoining pits to form a rectangle wherever they were put down in regular series.

Where only individual pits, or a group of two or three were put down, usually triangular or circular areas have been assumed for the calculations

7. *Occurrence of ilmenite sands on the Chowghat-Ponnani and the East Coasts*

CHOWGHAT-PONNANI COAST

(*Sheets 49-N/13, N/14, 58-B/2*).—The deposits (on the Chowghat Coast) occur along a strip of the shore in bands of varying concentration and thickness between Puthiyakadappuram, about 2 miles south of Blangad. and

Ponnani in the north, a distance of about 6 miles north of Blangad. Further north, the sands continue in patches up to Ponnani. The fairly promising belt extends from one mile south of the Government Fish Curing Yard, Blangad, to about 5 miles north of it having a width varying between 100 feet to 200 feet. But in some places the belt is reduced to 10 feet or less. The bands of concentrates vary in thickness from ½ inch to 1½ feet. Prospecting operations were confined to the area north of Blangad and only one mile to the south of it.

From Puthiyakadappuram to a distance of about 3 miles north of Blangad the face of the sand ridge representing the high watermark shows two or three bands of good concentrates of variable thickness. In some places the bands are 6 inches thick; but further northwards the concentration is definitely poor. South of Puthiyakadappuram the bands completely disappear.

The surface concentration near the sand ridge north of Blangad is fairly good within a belt of about 5 feet to 10 feet, but landwards it gets poorer. North of Blangad in the coconut grove belonging to Messrs. A. V. Thomas and Company, about 150 feet from the ridge, the surface sands are grey. A few pits put down in this area reveal the presence of 1 foot to 1½ feet of these sands below which bands 2 to 9 inches thick, of good concentrates are met with. Between the high and low watermarks bands of good concentration occur below the surface. The coast was examined up to the mouth of the Ponnani river, but in general, beyond 3 miles north of Blangad, the bands get somewhat narrower and poorer in concentration. The deposits on the Chowghat coast appear to be fairly promising. The results of magnetic separation of some of the samples are shown on page 587.

COASTS OF THE TINNEVELLY DISTRICT.

The best and the most extensive deposits in this district occur at the mouths of the Vaippar and the Kallar. These occurrences, however, stand no favourable comparison with the Travancore deposits. The results of magnetic separation of a few samples are shown on page 588.

(*a*) *Mouths of the Vaippar* (*58-K/8*).—This patch extends north-eastwards for about 4 miles from the right bank of the Vaippar almost up to Panaiyur. The width of the belt is variable. Generally it is 20 feet broad, but in some places bands of good concentration extend landwards for nearly 200 feet. On the right bank of the Vaippar, about 400 feet from the high watermark, there are three bands of ilmenite sands of good percentage. But the bands are comparatively thin, being 4 inches, ½ inch and 1 inch respectively. Some of the bands contain much garnet.

(*b*) *Mouth of the Kallar (58-L/1 and 5)*.—This patch occurs about 4 miles south-west of the mouth of the Vaippar and extends north-eastwards for about 2 miles from the right bank of the Kallar. The belt varies from 5 feet to 80 feet in breadth. The bands are also variable in thickness. This occurrence is about 14 miles north of Tuticorin.

Close to the sea near Veppalodai the sands are consolidated into a fairly hard rock with one or two bands of ilmenite of good percentage 1 to 2 inches in thickness. This bank is seen to extend for more than 400 feet in length.

(*c*) *Taruvaikkulam (58-L/1 and 5)*.—The area lies about 3½ miles further south-west of the Kallar patch mentioned above and extends for nearly 2 miles up to Taruvaikkulam. The belt containing bands of good concentrates varies from 5 feet to 100 feet in width. The results of magnetic separation of two samples are shown on page 588.

Besides the (two) occurrences mentioned above, there are several smaller patches of ilmenite sands met with along the Tinnevelly coast. But the tonnage is lower than in the case of the other two occurrences mentioned above, if the patches are considered separately.

(*d*) *Idindakarai (58-H/12)*.—A small band 3 inches to 4 inches thick of good percentage of ilmenite is found to extend for about ½ furlong disappearing just at the eastward bend of the coast. In front of the Government Fish Curing Yard there is a small area extending for about 100 yards and separated from the previous by a stretch of the coast which is practically sterile. The 3 inches band of ilmenite sands does not extend landwards for more than 4 feet. Just beyond the gulf west of Idindakarai, below the cliff, good concentrates could be collected. This patch does not extend for more than 20 feet. The band is a little over 6 inches in thickness.

Again, 2½ furlongs from the church, for a length of about 150 feet good surface concentration is met with. The thickness of the band is 2 to 3 inches and the belt is about 10 to 15 feet wide. A little east of this patch there is more of surface garnets.

Further eastwards, east of the big nala, about 40 yards of good black sands occur. The belt is about 20 to 30 feet wide.

The band of concentrate is not more than 1 inch in thickness. Here the monazite concentration is also fairly good.

About 100 feet from the above spot there is yet another patch extending for about 1½ furlongs eastward. At the face of the sand ridge representing the high watermark a band 9 inches to 1½ feet in thickness is met with. There are also one or two very thin bands of concentrates some of which show a fairly high percentage of garnets.

(e) *Avudaiyapuram* (58-*H*/16).—A pocket extending for about 1,700 feet occurs due south of the above mentioned village. This area also contains some thin bands of garnets. There is a 2½ feet band of black sands close to the sea towards the western end of the area. But landwards this band is split up into four or five thin strips varying from 2 to 4 inches in thickness. The belt varies from 5 to 10 feet.

After a barren area of about 4 furlongs there is again a stretch of good concentrates not exceeding 100 feet in length. At the western end of this patch there is a top band of about 9 inches of good ilmenite concentrates but eastwards the band gets generally thinned out. Towards the middle of the area two or three thin bands varying from ½ inch to 2 inches occur. The belt is 30 to 50 feet wide.

(f) *Mouth of the Nambiyar* (58-*H*/16).—At the mouth of the Nambiyar there is good superficial concentration of garnet sands extending almost up to Navaladi. This occurrence will be dealt with in a separate section, but it is mentioned here as in this long stretch a patch of ilmenite concentrates is observed extending for about 200 feet. Some of the bands also contain fairly good percentage of garnet. Beyond 200 feet purer bands of garnet are observed.

Just a little beyond the right bank ilmenite concentrates are visible. The belt is 10 to 30 feet in width. The bands are generally thin, the best being about 9 inches with a good percentage of garnet. About 200 to 300 feet from the right bank of the Nambiyar, surface sands near the high watermark show a fairly good percentage of monazite.

(g) *Mouths of the Tambraparni* (58-*L*/2).—Shankumukham Kovil island at the mouths of the Tambraparni shows ilmenite sands of fairly good percentage all along its seaward side. At the southern end there is a 4-inches band not more than 10 to 20 feet in width. Here the percentage is fairly high; but at the northern end of the island where the belt is only 10 feet wide, due east of the temple it appears to be nearly 20 feet wide.

North of the Shankumulliam Kovil island is another smaller island where the sands on the seaward side contain only traces of ilmenite and other heavy minerals.

(*h*) *Tuticorin* (*58-[illegible]/1 and L/5*).—About 1½ miles south of Tuticorin extending for about 1,400 feet is a narrow belt about 3 to 5 feet in width, of good ilmenite concentration. There are thin bands of good percentage about ½ inch to 2½ inches in thickness. But in this area at the mouth of a small nala on both banks a 9 inches band is observed on the top. But the area is limited to about 12 square feet.

Ilmenite sands of good concentration are seen due east of the church in the northern limits of the town. The patch extends northwards for over 4,500 feet. Up to 2,500 feet the two or three bands of good concentrates are very thin, ½ inch to 2½ inches in thickness. But beyond, slightly thicker bands (3 inches, 4 inches and 9 inches) are present. The belt varies from 7 to 10 feet in width.

Deposits in stream beds.—Good concentrates are also observed in some of the dry beds of streams but the available tonnage in all cases is found to be very low.

(*i*) *Vijayapati* (*58-H/12*).—The cart-track from Vijayapati to Idindakarai cuts across two small streams. In the bed of the second stream on the left side of the track ilmenite sands 1½ inches to 2 inches are met with. The concentrates are found in narrow bands in the river bed, 1 foot or 2 feet in width. Smaller quantities are also found on the right side of the track. The percentage of ilmenite is generally high. The concentrates can be traced for about a furlong eastwards until the rivulet joins a large stream.

(*j*) *Kuttankuli* (*58-H/16*).—About 4 furlongs along a nala just south of Kuttankuli good concentrates of ilmenite sands occur. The depth of the band varies from 1½ to 2 inches. The width is also variable, from 7 to 10 feet, being widest at the bends. The concentrates have been traced for nearly ½ mile up the stream. The elevated ground on the sides of the stream reveals sands of a predominating red colour with low percentages of ilmenite, manazite, etc. The concentrates in the stream beds are derived from the high ground. The results of magnetic separation of one sample are shown on page 588.

COASTS OF THE RAMNAD DISTRICT.

On the coasts of the Ramnad district small patches of ilmenite deposits are found: but none of the occurrences seems to be promising (*a*) *Valinokkam* (*58-L/12*).—The major part of the deposits occurs on the right bank of the Pal Ar extending for nearly 3,000 feet westwards. Westwards, the bands can be traced for nearly 1,000 feet. The concentrates are chiefly confined to the surface within a belt of about 3 to 7 feet. The thickness of the band does not exceed 2 inches and it is spread out between the high and low watermarks.

(*b*) *Kilakkarai* (*58-K/16*).—East of Kilakkarai there are three or four small patches each about ½ to 1 furlong in extent. The width of belt varies from 5 to 10 feet. The concentrates are confined to the surface, ½ to 1 inch in thickness.

(*c*) *Periya Pattanam* (*58-K/15*).—From the promontory due south of Periya Pattanam to the small cheek south-east of the village there is a small patch of ilmenite sands extending for about ¾ mile. There is only a single band, 1 inch to 2 inches in thickness of good concentration, the rest being of poor percentage. The belt is only about 5 feet broad.

(*d*) *Ariyaman* (*58-O/3 and O/4*).—Due north of Ariyaman caught up in a small gulf, are deposits of fairly good concentration of garnet sands extending for nearly 2,500 feet. In this area there is a thin band of about 1 inch thickness of good ilmenite sands. The belt is only 3 to 5 feet in width.

(*e*) *Sundarathasmadam* (*58-O/3 and O/4*).—About 1½ to 2 miles east of Mandapam and due east of Sundarathasmadam there is another patch about ¾ mile in length extending almost up to the rocky area ½ mile west of the Pamban bridge. At the western limits of this area there is more of garnet about ½ inch to 1 inch on top. But towards the east there is more of ilmenite (about ½ inch surface concentration).

(*f*) *The mouth of the Virisuli Ar* (*58-O/1 and O/2*).—On the left bank of the nala there is a 100-foot stretch of ilmenite concentrate of good percentage on the surface. The band is only ½ inch thick. Stretching from the right bank for about 300 feet in a belt of about 6 feet width, there are again good concentrates to be seen.

(*g*) *The mouth of the Pambar* (*58-O/1 and O/2*).—The Pambar splits into two or three branches before joining the sea. The different branches flow partly through the Ramnad and partly through the Tanjore districts. For the sake of convenience all the Pambar occurrences may be considered here.

South-east of Sundarapandivanpattanam, near the village, there is good surface concentration of ½ inch thickness of ilmenite sands extending for about 600 feet at the mouth of the southernmost branch. This belt is 3 feet wide.

Half a mile south-east of Pattukidapatnam, on the left bank of the northernmost branch, about 50 to 80 feet stretch of good concentration is seen.

On the left bank of the third branch, extending for a distance of about 900 feet a patch of good percentage occurs ; and on the right bank the belt, 3 to 5 feet wide extends for 50 to 70 feet. In this area there are two narrow bands varying in thickness from ½ to 1 inch. Between the low and high watermarks for a length of about 600 feet along the coast, the concentration is good, but the thickness of the band is only ¼ to ½ inch.

COASTS OF THE TANJORE DISTRICT

Of the several occurrences met with, chiefly small patches, the one found near Tranquebar may be considered to be comparatively important.

(*a*) *Tranquebar* (*58-M/16*).—The deposits extend from Tranquebar northwards to a distance of about 1½ to 2 miles. The bands of good concentration vary in thickness from ½ to 1 inch. The width of the belt is also very variable, being in some places nearly 100 feet. The thickness of the bands gets reduced landwards. The bands generally contain a high percentage of ilmenite. Northwards, beyond Manikkappangu the percentage gets poorer. South of Tranquebar the deposits are reduced to one or two thin bands of good contentration extending a little beyond the Uppanar. The results of magnetic separation of a few samples are shown on page 588.

Other occurrences of smaller patches are mentioned below.

(*b*) *Tirumullaivasal* (*58-M/16*).—Just south of Tirumullaivasal a patch of ilmenite sand extends for about 1½ miles southwards almost up to Kanayampattanam. The surface concentration in this area is rather too poor, but a few thin bands with good ilmenite percentage varying in thickness from ½ inch to 2 inches exist below the surface. Some of the bands show a high percentage of garnet the bands varying from ½ inch to 8 inches in thickness. The area between the high and low watermarks contains little or no ilmenite.

In the area between the Tirumullaivasal and Tranquebar patches, the surface concentration is poor, but one or two thin bands occur below the surface.

(*c*) *Mouth of the Coleroon* (*58-M/15*).—South of Kodiyampalaiyam there is a patch of ilmenite sands at the mouth of the Coleroon. This belt occurs some distance from the coast in front of a line of dunes and about 200 to 300 feet east of the mangrove vegetation. There are slight traces of ilmenite on the surface, but within a depth of 1 foot to 2 feet there is a band of about 6 to 9 inches of fairly good concentration. The belt appears to extend for less than 1,500 feet and does not seem to exceed 30 to 40 feet in width. The thickness of the bands is also variable, but generally quite thin.

Due east of Pudupattanam just beyond the stream that runs north to south, and about 1½ furlongs from the sea a narrow belt of about 10 to 20 feet wide and about 500 feet in length occurs. In this area there is a thin band of about 2 inches of good ilmenite concentrates about 1½ feet below the surface.

On the left bank of the Coleroon about 100 feet or so southwards is another patch extending for nearly 300 feet. The concentrates are chiefly found superficially between the high and low watermarks in a belt 5 to 10 feet wide. In this belt there is a barren length of about 500 feet. The concentrates are in thin bands ½ inch to 2 inches in thickness

(*d*) *Between Mimisal and Adirampatnam.* (*58 O/1 and O/2, N/4, N/7 and N/8*).—Small patches of ilmenite concentrates of good percentage are seen at the mouths of the small nalas The patches are usually 100 to 500 feet in length and the belt is generally narrow varying from 1 foot to 5 feet. The sands are usually spread out as surface concentrates, or, if below the surface, the bands are very thin. Small quantities of ilmenite sand of good percentage can however be collected from some of these areas.

(*e*) Along the coasts of the Negapatam taluk traces of ilmenite are noticeable. In the older dunes a thin layer of ilmenite or garnet concentration is easily visible at a distance.

8. *Separation of minerals in the laboratory*

As a preliminary step to separation, the samples were washed free of traces of sea salt and dried, as otherwise, the salt content tended to attract moisture from the atmosphere and to move the sand grains in lumps towards the magnet, including the various minerals in the lumps.

Besides grading, panning and vibration, several physical methods of isolating the various minerals contained in the ilmenite sands are available, depending on the differences of specific gravity of the component minerals (heavy liquid separation) magnetic permeability (electro-magnetic separation), electrical conductivity (electro-static method) and surface tension (oil flotation). No one method can be used with complete success, but a combination would give a fairly clean separation of the minerals.

With the limited facilities available at the Geology Department, Presidency College, Madras, I had to depend almost entirely on the method of electro-magnetic separation. The electro-magnet available was not only not powerful, but it had the added disadvantage of being the "erect inverted type". The results obtained with this type of electro-magnet were far from satisfactory.

Owing to the high cost of heavy liquids it was found not practicable to use them. But a combination of methods such as separation by heavy liquids followed by magnetic separation would have given satisfactory results. Preliminary screening and vibration were also tried wherever they were found advantageous.

The highly magnetic grains of magnetite were first removed by means of an ordinary laboratory horse-shoe magnet. But it was found that, owing to the force of attraction, a few grains of other less magnetic minerals were also mechanically enmeshed with the magnetite. Almost pure magnetite crops could be obtained by repeating the process.

The residue well spread out into a thin layer on a stiff cardboard was then treated with the electro-magnet. The grains were placed in successively stronger fields, thus removing the minerals in the order of decreasing susceptibility. The intensity of the field was controlled by increasing the current, reducing the distance between the poles and also the distance between the cardboard and the magnetic poles.

A single battery was used as the source of current. As the, electro-magnet used was not a powerful one, the grains had to be held almost touching the poles, and while separating the feebly magnetic from the non-magnetic, the grains had to be brought almost in contact with the poles.

The following table gives at a glance the procedure adopted:—

Sample.

Treated with horse-shoe magnet.

(1) Magnetite and
Titaniferous magnetite.

Residue

Treated with electro-magnet

Poles 4 mm. apart—	
(2) 0·5 amp.	Ilmenite with some garnet towards the tail end ; some ilmenite left over.
(3) 1·0 amp.	Garnet with remaining ilmenite ; Epidote and other minerals; some epidote left behind.
(4) 1·5 amp.	Remaining epidote with some monazite and other less magnetic minerals.
Poles 2 mm. apart—	
(5) 3·5 amps.	The rest of the monazite and other feebly magnetic minerals.
(6) Final residue	Quartz, zircon, sillimanite, rutile and other non-magnetic minerals.

From the above scheme, it would be clear that almost clean separations could be obtained only in the case of (1) magnetite and (2) ilmenite with a portion of ilmenite left over. The other separations, (3), (4), (5) were alwaye mixtures in spite of repeated trials under varying fields. Owing to the high cost of chemicals heavy liquid separation which would have achieved the desired purity of the concentrates could not be tried. Panning of the magnetically separated concentrates was not quite successful. It was therefore considered advisable to give the percentage of (1) magnetite (highly magnetic mineral), (2) ilmenite (moderately magnetic mineral), (3) mixture of ilmenite, garnet, epidote, monazite and certain other minerals (feebly magnetic), (4) quartz, zircon, felspar and other minerals (non-magnetic).

Disadvantages of the electro-magnetic method of separation.—While working with the electro-magnet several practical difficulties were encountered some of which could be circumvented. (1) Compound grains made up of more than one mineral, usually quartz and magnetite, or quartz and ilmenite easily influence magnetic separation. (2) Separations are not always clean as minerals lying along the border line may go into either group. (3) When grains of magnetic minerals are attracted to the poles, other grains which do not actually belong to the particular category may also be brought up and held due to the slight cohesion between the grains. The error due to this can however be minimized by repeating the process more than twice. (4) When the sands are fine grained, the grains are attracted in lumps to the poles and clean separations in such cases are not possible with the electro-magnet. (5) The same difficulty is encountered in the case of samples composed of ordinary-sized grains when moist.

9. *Table showing the results of magnetic separation.*

In the following tables data on monazite are deliberately omitted.

A. Chowghat-Ponnani Coast (West Coast)

Sample number.	Magnetite.	Ilmenite.	Garnet with ilmenite and also other weekly magnetic minerals.	Zircon, quartz and other non-magnetic minerals.
	Per cent.	Per cent.	Per cent.	Per cent.
1	10·8	57·4	22·8	9
2	13·78	59·75	15·5	11
3	3	73·75		23·25
4	17·25	66·75	7·25	8·75
9	10·25	63	26·75	
10	18·5	66·75	..	14·75
14	6·25	33	31·5	29·25
16	4	60·5	35·5	
19	12·25	58	16	13·75
21	16	61·5	22·5	
25	9	54·5	26·75	9·75
27	7·5	46·25	35·75	10·5
30	10	58·5	19·5	12
33	18·25	66·25	8·5	7
An average sample	9	49·25	24	17·75

B. East Coast.

Sample number and name of locality.	Magnetite.	Ilmenite.	Ilmenite and garnet and other weakly magnetic minerals.	Quartz, zircon and other non-magnetic minerals.
	Per cent.	Per cent.	Per cent.	Per cent.
46 Streambed (Kuttankuli) . .	1	91	7	1
63 Punnakayal	2	34·75	58·75	9·5
66 Tambraparni (mouth) . . .	Very fine grained, could not be separated.			
68 Taruvaikulam	11	62·6	18	7·5
69 Do.	1	80·75	10	8·25
An average sample from Taruvaikulam .		52		
72 Vaippar-Kallar	2	53	38·25	6·75
76 Do.	6·75	73·75	12·25	7·25
An average sample, Vaippar-Kallar .		49·5		
93 Mouth of the Pambar	2·75	85·25	2	10
98 Tranquebar	19·75	63·75	8·75	7·75
100 Do.	12·5	64·	18·5	5
104 Do.	15·25	61·75	18·75	4·25
107 Do.	1·5	87·5		11
108 Do.	11·2	62·4	21·4	5
An average sample, Tranquebar . .		50·5		
114 Tirumullaivasal	9·75	55·25	30	5

10. *Available tonnage*

Of the several patches of ilmenite sands only three need be considered as comparatively important, namely, (1) the Chowghat-Ponnani deposit (Malabar district, West Coast), (2) the Vaippar-Kallar deposit (Tinnevelly district, East Coast) and (3) the Tranquebar deposit (Tanjore district, East Coast).

The probable available tonnage of the more important minerals except monazite in the three regions is tabulated below:—

Area.	Ilmenite.		Magnetite.		Zircon.		Garnet	
	Average per cent.	Tons.	Average per cent.	Tons.	Average per cent.	Tons.	Average per cent.	Tons.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Chowghat-Ponnani . . . (Malabar Coast) . . .	49·25 50·0	915,610	10	10,173	5	9,562	15	12,818
Vaippar-Kallar . . . (Tinnevelley District) . .	49·5 52·0	31,916	3	2,130	6	1,505	16	9,535
Tranquebar . . . . (Tanjore District) . . .	50·0 50·5	80,607	12	7,027	6	3,223	12	4,801

A few thousand tons of ilmenite and correspondingly lower tonnage of the other minerals may be available from the smaller patches of the black sands on the east coast. On the whole the tonnage in the Vaippar-Kallar and the Tranquebar deposits is rather low; in the Chowghat-Ponnani area it is better but still moderate.

11. *Method of mining*

Since the ilmenite deposits occur as beach sands their working is easy. The sands may be dug up by manual labour. In places where the concentrates occur in bands, the sterile bands may be removed and only the better bands worked. Wherever found practicable, the sands collected could be carried in ordinary closely woven baskets or metallic containers as head loads and taken to a factory where the separation is carried out. The factory may be established not far away from the working spot.

NOTE.—The percentages of the different minerals are approximate and therefore their tonnage tabulated must be taken with reserve. Data on Monazite are deliberately omitted.

A trolley line to carry the raw material for concentration should be advantageous where the deposits are large enough to permit of such capital expenditure.

12 *Commercial treatment of minerals*

The concentration of the heavy minerals contained in the sands is a comparatively cheap process The sands may be concentrated on a series of "wet tables" or sluice boxes lined with cloth and set at an inclination of, say, 1 in 20. The tables or sluice boxes should be set with rifles which help to retain the heavier mineral at the upper end The tailings may be washed further. A good part of quartz and other lighter minerals can thus be removed from the sands. The concentrates, after drying, may be treated first in a low magnetic field to remove the magnetite and then treated with a powerful electro-magnet. By varying the intensity of the magnetic field, the various minerals are separated according to their magnetic susceptibility. 'Lift' type and "Deflection and Lift" type of separators are both used by the Travancore Minerals Company, in their factory at Manavalakurichchi in the Travancore State.

A considerable degree of purity of the concentrates can be achieved by using other methods also, such as recourse to an electrostatic separator.

By far the largest part of the concentrate is composed of ilmenite, the other minerals, mentioned above, although found in much smaller proportions, will form valuable by-products.

13. *Transport and other facilities*

Facilities of transport have a direct bearing on the cost of marketing. In the case of the three more important areas this question is considered separately below:—

(a) *Chowghat-Ponnani Coast.*—The best part of the deposit in this area lies west of Manatala, a village which lies nearly one mile from the coast. Manatala itself is about 16 to 18 miles from Trichur, the nearest railhead situated in Cochin. The Shoranur railway station is over 22 miles away connected by a good road to Manatala The area between Manatala and the coast is quite sandy and there is no proper road at present leading to the coast.

The most economical form of transport under the existing conditions will be the use of country boats which can be engaged for removing the concentrates by sea to some other part of the coast for the chemical treatment of the ores, if such ventures are undertaken. Through the mouth of the Kanniramukku, north of Veliyangod or the Chetwayi river south of Blangad, the Ponnani canal can be reached through which communication is possible up to the railhead of Trichur in the south-east and Tirur in the north. During the south-west monsoon it will be difficult to use country boats along the coast.

Between Veliyangod and Blangad, the stretch where the best deposits occur, there are no large streams. A trolley line may have to be laid along this stretch to carry the load of sands to the factory for concentration.

The water-supply at and near the coast is generally brackish. In addition the Ponnani-Chowghat belt is also reported to be filarial.

(*b*) *Vaippar-Kallar area.*—Land communications in this area are very poor The unmetalled road leading to Veppalodai salt pans is badly maintained and it touches a part of the deposit which extends further northwards beyond the mouth of the Vaippar. West of this area is a long stretch of swamp.

There is a second-class road extending from Vilattikulam to half-way up to the village of Vaippar. The rest of the track is quite sandy.

There is no canal system and the Vaippar is practically dry except after heavy rains in the hills so that communication by boat to the interior is impossible.

Except for a short period during the north-east monsoon, country boats can however be used along the coast to carry the sand to a place where they may be concentrated.

There are several streams between Taruvaikkulam in the south and Panaiyur in the north so that the laying down of a trolley line will be costly; besides, the distance between the two places is nearly 16 miles, the productive areas lying in three distinct patches near Vaipar, Veppalodai and Taruvaikkulam. The deposits of the three areas considered as a whole, are not likely to last long enough to justify the expenditure on the construction of a trolley line. The port of Tuticorin is only about six miles south of Taruvaikkulam.

Water-supply.—There is difficulty in obtaining a supply of potable water in this area. The Veppalodai salt factory at present receives its fresh water-supply by cart from Panaiyur, nearly three miles from the coast. The village of Vaippar taps water from pits dug in the dry bed of the Vaippar river.

(c) *Tranquebar.*—Is a railway station and there is a good motorable road up to the fort which is situated very close to the shore.

The best deposits occur between Tranquebar and Manikkapangu and there are no streams between the two villages. It will not be difficult to lay a trolley line to feed the factory with raw sand, but the deposits are limited in size and are not likely to last long.

Country boats plying along the coast can also be used for carrying the raw sand.

Water-supply.—There is ample supply of fresh water at Tranquebar.

14. *Industry*

No serious attempt has been made in India till quite recently to utilize ilmenite, monazite, zircon, or rutile in any manufacturing process. It has been the practice to export the concentrates to manfacturers overseas, although this country at present holds a controlling share of the world's production of monazite and ilmenite sands. There is no reason why further treatment of these valuable ores should not be attempted in this country.

Ilmenite.—Besides the manufacture of titanium pigments, titanium alloys such as ferro-titanium and ferro-cupro-titanium may be attempted in India. For the manufacture of mangano-titanium and cupro-titanium used in mixing brass and bronze and for titanium tetrachloride for smoke screens rutile is generally in demand.

The advantage of titanium dioxide over zinc oxide and white lead as a pigment depends on its general inertness, great hiding power and lack of selective absorption of light which gives it intense whiteness. It is used in lacquer enamels and as ordinary white paint.

Titanium chloride and titanium sulphate are used as effective stripping agents in the dye industry. Titanium oxide and carbide are used in the manufacture of electrodes in arc lamps.

Zircon.—Zirconia is an excellent refractory material not easily attacked by corrosive slags; useful laboratory wares like crucibles and combustion tubes are now manufactured out of zirconia. It is used as an opacifier in enamels, as a toughening agent in vulcanizing, in the manufacture of flash light powders and also in the paint and tanning industries.

Zirconium-steel alloy has excellent shock resisting properties and is used for armour plates. Zirconium-nickel alloy is a hard and non-rusting cutting metal. Zirconium-columbium-tantalum alloy is highly resistant to corrosion and is used as laboratory ware in place of platinum.

Monazite.—The percentage of this mineral is very low in the deposits examined, but as a by-product it is a valuable component. At one time there was great demand for the mineral for the manufacture of cerium nitrate for gas mantles. There are various other uses for cerium compounds in medicine, tanning and dying industries, photography and in the manufacture of pyromorphic alloys. An alloy with tungsten is used in lamp filaments. The phosphate content in the mineral can also be advantageously used.

Mesothorium, because of its possessing properties very similar to those of radium, is being used in therapy in place of radium and also in the manufacture of luminous paints. Thorium has now come into great prominence as an important strategic material.

II. GARNET SAND

1. *Distribution*

Garnet in varying proportions is met with along the Chowghat-Ponnani Coast and the coasts of the Tinnevelly, Ramnad and Tanjore districts. The best deposits are found in southern Tinnevelly, a little removed from the high water mark behind a row of dunes in the Ovari-Navaladi area.

It would suffice to add here that wherever ilmenite is found to occur, whether in the coastal sands, in the dry beds of streams, white or younger dunes, red *teris* or older dunes or in tank beds, garnet is also seen to occur with it in varying proportions.

2. *General characters of the deposit*

Such deposits that lie between the high and low water marks are all small in size and show more or less the same characteristics as in the case of the ilmenite sands. The better deposits of Ovari-Navaladi occurring behind the row of dunes a little removed from the high water mark, are not materially affected by seasonal changes. Strong winds that blow over the areas help to concentrate the surface sands as the lighter minerals are easily blown away.

3. *Minerals*

The minerals contained in the shore deposits between the high and low water marks are the same as those of the ilmenite sands considered above, only the proportion is different.

But in the Ovari-Navaladi deposit lying some distance away from the shore, the heavier minerals are hardly present. There are only traces of ilmenite, magnetite and zircon. Quartz and shell fragments are not unusual components.

The size of the grains of garnet in the useful deposits is usually larger, so also of the other minerals present. The larger size may be attributed to the fact that the deposits occupy slightly high ground beyond the high water mark so that there is no rapid reduction in the grain size by the action of the waves. If the sizes of the grains of the various minerals present in the

Ovari-Navaladi area are compared the lighter minerals are generally seen to be of a larger size.

The size and percentage of the various minerals in the more useful deposits are given below:—

Garnet.—Percentage is nearly 77·5 in the good samples. The mineral is of the almandine variety.

Ilmenite.—Present only in traces; shows larger grain size.

Monazite, zircon and magnetite.—Occasional traces present, but in one deposit near Kuttankuli on a high ground monazite was found in good concentration.

Quartz, felspar and shell pieces amount to about 20·5 per cent. of the sands. Rutile, amphibole, sillimanite or other minerals have not been met with so far.

The following table gives the percentage of the various minerals in some of the samples. Sample No. 51 is from a heap of garnet concentrate kept ready for shipment to Bombay:—

Sample number and locality.	Magnetite.	Ilmenite.	Garnet.	Quartz felspar, zircon, shell pieces, etc.
	Per cent.	Per cent.	Per cent.	Per cent.
51 Concentrate, Navaladi .	..	2	88·25	9·75
52 South west of Nambiyar, Kuttankuli	Trace.	32·75	53·25 with ilmenite and other minerals.	14
61 South of Semponvilai (Ovari-Navaladi area).	..	2	77·5	20·5
An average sample from south-west of Nambiyar Kuttankuli.		25	45	

4. *Sources of Garnet*

Owing to the high percentage of garnet it is surmised that the minerals in the sands in all probability were derived chiefly from the garnetiferous gneisses and leptynites, and partly from the pegmatites. The red *teris* or dunes do not apparently contribute much as in the case of ilmenite sands in the Tinnevelly district,

5. *Prospecting*

Prospecting was carried out as in the case of the ilmenite sands, but as the more useful deposits in the Ovari-Navaladi area are underlain by certain calcareous sandstone and shell limestone of probable Pleistocene or sub-recent age within a depth of 3 to 6 feet, the depth of the prospecting pits was governed by the depth at which the rocks were met with from the surface.

Expenses for putting down pits were low as in the case of the areas of the ilmenite deposits.

6. *Separation of mineral in the laboratory*

Preliminary screening was found useful before separation by electro-magnet. The minerals garnet and quartz, and shell pieces are of larger size so that a good part of the above ingredients of the sand could be separated by a preliminary screening. It is then followed by electro-magnetic separation as in the case of the ilmenite sands.

7. *Occurrence of Garnet sands on the Tinnevelly Coast*

There are two important areas in the Tinnevelly district where garnet sands occur: (*a*) Ovari-Navaladi area, (*b*) Kuttankuli area. These deposits occur a short distance from the sea behind a row of dunes.

(*a*) *Ovari-Navaladi area*—(*58 H/15*).—This area has been under exploitation now for nearly 30 years. There are three productive patches in this area: (1) near Ovari, (2) near Navaladi, (3) between the two due south of Seponvilai. The patch near Ovari has already been worked out but the old pits are now being gradually filled up by garnet sands from the neighbouring areas blown by the wind. Some quantity of garnet could be reclaimed at present from this area.

The patch near Navaladi is now being exploited. In this area there is yet some reserve of garnet sands of good percentage.

The third patch south of Seponvilai occupies an area of about six acres of garnet sands of good percentage. This promising areas has not been worked so far, as the ownership of the property is in dispute. The surface concentration in this area is good and is continued to a depth of 4 feet or more up to the hard rock. In some places, however, the thickness of the garnet band is less than 3 feet.

(*b*) *Kuttankuli area* (*58-H/16*).—About 3 furlongs south-west of the Nambiyar and 400 feet from the shore there is a patch of garnet sands of good percentage extending for about 1½ to 2 furlongs south-westwards. The concentration dwindles appreciably further southwards. A thin surface band (1 to 2 in.) contains, besides a fair percentage of garnet, some ilmenite and also a fair proportion of monazite (2 per cent.). A band of yellow sand about 3 to 4 inches in thickness intervenes between the top band and a fairly thick 3 feet band of good garnet concentration. This belt is about 100 yards in width.

Besides the areas mentioned above, there are other localities where fairly good garnet sands are met with, but the deposits are quite small.

(c) *Vijayapati* (*58-H/16*).—About one-fourth mile south-east of Vijayapati a superficial concentration of garnet sands, about 1 inch to 3 inches in thickness, is met with over an area of about 3 acres. Test pits did not reveal any deeper occurrence.

(*d*) *From the mouth of the Nambiyar* (*58-H/16, 15*).—Half a mile south-east of Navaladi good percentage of garnet sands occur between the high and low watermarks in a belt varying in width from 3 to 10 feet. The sands are chiefly found as superficial concentrates washed by waves, but a few thin bands also occur below the surface.

(*e*) *Kalimankundu* (*Ramnad district*) (*58-K/15, K/16*).—Due south of Kalimankundu which lies south-west of Periya Pattanam, there is a belt of garnet sands about 4 furlongs in extent. The belt is only 5 to 7 feet wide. The band occurs about 1 foot below the surface and is from 2 to 4 inches thick.

(*f*) *Ammankudi* (*Ramnad district*) (*58 O/3 and O/4*).—A fairly good surface concentration is observed just west of the mouth of the nala which spreads out on the northern side of the railway line. This area lies due north of Ammankudi. The extent of the band along the coast is nearly 2,800 feet. The belt varies in width from 2 to 4 feet. The bands are thin, being ½ inch to 2 inches in thickness. In this area, as already mentioned, patches of ilmenite sands are also met with.

8. *Available tonnage*

Of the few patches of garnet sands described above, only two occurrences need be considered here as they are the more useful deposits.

The probable reserves in the (i) Ovari-Navaladi area is about 36,000 tons and (ii) the Kuttankuli area is about 20,000 tons. About 500 tons of monazite and a few thousand tons of ilmenite may also be won from the latter area. From the other areas not mentioned here, a few hundred tons may be available.

9. *Method of mining and commercial treatment of minerals.*

The Ovari-Navaladi area is now being exploited. At present the contractors are scooping out the sands by manual labour only from the more payable areas. The raw sand is carried as head loads in baskets and piled up in an exposed spot near the pit where concentration of the sand is carried out by the simple method of "winnowing". The raw sand is allowed to fall in a thin stream from tilted baskets held in the hands of the labourers. The heavier grains of garnet and also the few grains of the heavy minerals fall on a reed mat spread on the ground below the basket. The lighter quartz grains and particles of shell are blown further away by the breeze. The process is repeated twice or three times and the concentrates filled up for export by sea in country boats.

Samples thus concentrated gave only 88 5 per cent. of garnet. Random sample from the Ovari-Navaladi area however gave 77·5 per cent. garnet.

The percentage of garnet in these "winnowed" concentrates can certainly be improved by using slightly better methods of concentration. They can at least be further screened and if necessary treated on locally made "wet tables" before shipping to factories manufacturing abrasives. Screening with sieves of different mesh size would enable the grains of garnet to be graded according to size for the manufacture of coarser or finer grades of garnet papers or discs.

The percentage of ilmenite and zircon is very low, the former a little over 2 per cent. and the latter perhaps still less. It is doubtful, therefore, if electro-magnetic separation is really very necessary if the garnet is to be used as an abrasive. The amount of ilmenite and zircon which may be available as by-products after a magnetic separation will also be very low.

The best stretch between Ovari and Navaladi is about 4 miles in extent, the workable deposits occurring in three patches. The present method of working may be generally continued, with the addition of screening and "wet table" treatment after "winnowing". It may also be suggested that, in order to avoid wastage, a more systematic mining may be followed instead of merely scooping out the best parts of the deposit.

10. *Transport and other facilities*

In the Ovari-Navaladi area communications with the interior are difficult. There are no roads connecting any place in this area with the interior. A long stretch of the red *teris* extends along the coast west of the garnet bearing area Even bullock cart traffic between Ovari and Tisaiyanvilai is very difficult. Although there is a stretch of a second-class road for a short distance of about a mile between Ovari on the coast and Idaiyankudi about 1½ miles south-south-west of Tisaiyanvilai, without an extension of the road to Idaiyankudi, even cart traffic will continue to be very difficult.

The concentrated garnet sands can however be loaded into country vessels and shipped to reach destinations as it is now being done.

Water-supply.—Good potable water is available in the Ovari-Navaladi stretch of the coast.

12. *Industry*

Garnet sand is used in the manufacture of abrasives such as garnet paper, cloth discs, etc. Graded crystals obtained *in situ* from the rocks are, however, more valued than the sands. The latter, being water-borne, are generally much worn and devoid of angles and sharp points as the material collected *in situ* and crushed. The much smaller grains of garnet met with on the shore between the high and low water marks are not of much use as abrasives.

The deposits in the Ovari-Navaladi area, being located above the high water mark, are composed of larger grains and are not much rounded. They can either be used directly or after slight crushing. The sands may be graded according to size to suit the grades of abrasive papers.

Some of the grains though clear, are too small to be used as gem-stones.

Alphabetical list of some of the more important localities with their co-ordinates

Adirampatnam . . .	58 N/7, 79° 23′:10° 20′ 20″.
Agastyampalli . . .	58 N/15, 79° 51′:10° 21′.
Arthat	58 B/2, 76° 3′:10° 37′ 30″.
Arumuganeri . . .	58 L/2, 78° 5′ 30″:8° 34′.
Aryaman	58 O/3 & 4, 79° 4′:9° 7′ 20″.
Avudaiyapuram . . .	58 H/16, 78° 46′ 10″:8° 11′ 4″.
Blangad	58 B/2, 76° 1′ 30″:10° 33′ 30″.
Chetwayi . .	58 B/2, 76° 2′:10° 32′.
Chittarkottai	58 K/15, 78° 54′:9° 25′ 40″.
Chowghat (Chavakkad) .	58 B/2, 76° 2′ 30″:10° 35′.

Devipattanam	58 K/15, 78° 54′:9° 28′ 30″.
Idaiyankudi	58 H/15, 77° 53′:8° 18′ 40″.
Idindakarai	58 H/12, 77° 44′ 40″:8° 10′ 40″.
Kadambakulam	58 L/2, 78°:8° 35′.
Kalimankundu	58 K/15, 78° 53′ 30″:9° 15′ 10″
Kallar (Mouth)	58 L/1 & 5, 78° 12′ 30″:8° 57′ 10″.
Kayalpattanam	58 L/2, 78° 7′ 30″:8° 34′.
Kilakkarai	58 K/16, 78° 47′.9° 14′.
Kudankulam	58 H/12, 77° 42′ 30″:8° 11′ 20″.
Kulasekarapatnam	58 L/3, 78° 3′:8° 24′.
Kuttam	58 H/15, 77° 56′ 10″:8° 19′.
Huttankuli	58 H/16, 77° 47′:8° 13′.
Kuttapuli	58 H/12, 77° 36′:8° 8′ 40″.
Manappad	58 L/3, 78° 3′ 30″:8° 22′ 30″
Manattala	58 B/2, 76° 1′ 30″:10° 34′ 40′,
Manavalakurichi	58 H/8, 77° 18′:10° 9′.
Mandapam	58 O/3 & 4, 79° 9′:9° 17′.
Manikkappangu	58 M/16, 79° 51′ 30″:11° 3′ 30″.
Mimisal	58 O/1 & 2, 79° 8′ 30″:9° 55′.
Mukkaiyur	58 K/8, 78° 29′:9° 7′ 40″.
Nambiyar (Mouth)	58 H/16, 77° 48′:8° 14′ 10″.
Nambutalai	58 O/1 & 2, 79° 0′ 30″:9° 43′ 30″.
Navaladi	58 H/15, 77° 49′ 50″:8° 15′ 20″.
Negapatam	58 N/13, 79° 51′:10°45′ 30″.
Ovari	58 H/15, 77° 53′ 30″:8° 16′ 30″.
Pamban	58 O/3 & 4, 78° 13′:9° 17′.
Pambar (Mouth)	58 O/1 & 2, 79° 7′:9° 51′.
Panaiyur	58 K/8, 78° 19′ 30″:9° 3′.
Panaiyur	58 L/1 & 5, 78° 11′:8° 59′ 20″.
Pattukkidapatnam	58 O/1 & 2, 79° 7′:9° 52′.
Periya Pattanam	58 K/15, 78° 54′ 30″:90° 16′.
Peyanvilai	58 L/2, 78° 6′ 20″:8° 34′.
Point Calimere	58 N/15, 79° 49′ 30″:10° 17′.
Ponnani	49 N/13, 75° 55′ 30″:10° 46′.
Pudumatam	58 K/15, 78° 59′ 30″:9° 16′ 30″
Punnaiyadi Tivu	58 L/1 & 5, 78° 12′ :8° 45′ 30″
Sayalkudi	58 K/8, 78° 27′:9° 10′.
Semponvilai	58 H/15, 77° 50′ 40″:8° 15′ 20″.
Sundarapandiyanpattanam	58 O/1 & 2, 79° 6′:9° 50′ 20″.
Sundarathasmadam	58 O/3 & 4, 79° 10′:9° 17′.

Surangudi	58 K/8, 78° 19′ 10″:9° 6′ 30″.
Taruvaikkulam	58 L/1 & 5, 78° 10′:8° 53′ 30″.
Tiruchendur	58 L/3, 78° 7′ 3″:8° 30′.
Tirumullaivasal	58 M/16, 79° 50′:11° 14′.
Tirur	49 N/13, 75° 55′:45° 55′.
Tisaiyanvilai	58 H/15, 77° 52′:8° 20′.
Tondi	58 O/1 & 2, 79° 1′:9° 44′ 30″.
Tranquebar	58 M/16, 79° 51′ 30″:11° 1′ 30″.
Trichur	58 B/2, 76° 13′:10° 31′.
Tuticorin	58 L/1 & 5, 78° 9′:8° 48′.
Vaippar	58 K/8, 78° 15′:9° 1′ 30″.
Valinokkam	58 K/12, 78° 39′:9° 9′ 40″.
Vedaranniyam	58 N/15, 79° 51′:10° 22′.
Veliyangod	49/14, 75° 56′ 30″:10° 43′ 30″.
Vembar	58 K/8, 78° 21′ 40″:9° 5′.
Veppalodai	58 L/1 & 5, 78° 13′:8° 57′ 50″.
Vijayapati	58 H/12, 77° 45′:8° 11′ 30″.
Virisuli (Mouth)	58 O/1 & 2, 79° 3′:9° 46′.

REFERENCES

BOWIE, S. H. U. and HORNE, J. E. T. (1953).—Cheralite, a new mineral of the monazite group. *Mineral Mag.*, Vol. XXX, No. 221.

CHACKO, I. C. (1917).—Report on the survey of monazite sand deposits *Trivandrum.*

HOLLAND, T. H. (1910).—The charnockite series. *Mem. Geol. Surv. India,* Vol. XXVIII.

JACOB, K. (1944).—The occurrence of ilmenite and garnet sands on the Chowghat-Ponnani coast (West Coast) and on the coasts of the Tinnevelly, Ramnad and Tanjore districts (East Coast). *Govt. of Madras, Dev. Dept.,* G. O. No. 3088.

JOHNSTONE, J. S. (1916).—Recent work on monazite and other thorium minerals in Ceylon. *Bull. Imp. Inst.,* Vol. 14.

TIPPER, G. H. (1914).—The monazite sands of Travancore. *Rec. Geol. Surv. India,* Vol. XLIV, pt. 3.

WADIA, D. N. (1952).—Research on Measurement of Geological Time in India—1947—50. *Journ. Sci. Industr. Res.,* Vol. IIA, No. 9.

The following may also be referred to:

Ilmenite: General report of the Geological Survey of India for the year 1952 (1954).—*Rec. Geol. Surv. India,* Vol. 86, Pt. 1.

Ilmenite: General report of the Geological Survey of India for the year 1947 (1948).—*Rec. Geol. Surv India,* Vol. 81, Pt. 1.

Ilmenite: General report of the Geological Survey of India for the year 1948 (1950).—*Rec. Geol. Surv. India,* Vol. 82, Pt. 1.

Ilmenite: General report of the Geological Survey of India for the year 1949 (1951)—*Rec Geol Surv India,* Vol. 83, Pt. 1.

Ilmenite: General report of the Geological Survey of India for the year 1950 (1953)—*Rec. Geol. Surv. India,* Vol. 84, Pt. 1.

Ilmenite: General report of the Geological Survey of India for the year 1952 (1954).—*Rec.. Geol. Surv. India,* Vol. 86, Pt. 1.

Ilmenite: Monzite Sands and Ilmenite-sand: General report of the Geological Survey of India for the year 1951 (1954)—*Rec. Geol. Surv. India,* Vol. 85, Pt. 1.

DUTTA, R. K. (1953)—Extraction of Thorium and Cerium from Monazite sands of Travancore: Pt. I, *Journ. Sci. and Industr. Res.,* Vol. 12B, No. 10.

DUTTA, R. K. AND DUTTA, N. K. (1953).—Extraction of Thorium and Phosphoric acid from Monazite sands of Travancore: Pt. II, *Journ. Sci. & Industr Res.,* Vol. 12B, No 10.

MAHADEVAN, C. AND SATHAPATHI, N. (1948)—The home of Monazite in the Vizagapatam area. *Curr. Sci.,* Vol. 17, No. 10.

MAHADEVAN, C. AND SRIRAMADAS, A. (1948).—Monazite in the beach sands of Vizagapatam District. *Proc. Ind. Acad. Sci.,* Vol. 27A, No. 4.

ROY CHOWDHURY, K. P. AND SINGH, R. (1954)—Production of Sillimanite refractories from Travancore Beach Sand Sillimanite. *Journ. Sci. & Industr. Res.,* Vol. 13B, No 4.

SRIRAMADAS, A. (1951).—The black sand concentrates of the Vizagapatam beach. *Quart. Journ. Geol. Min. & Met. Soc. India,* Vol. XXIII, No. 4.

VISWANATHAN, P. (1946).—A note on the investigation of radioactive mineral, *viz*, Zircon to determine its geological age *Sci. & Cult.,* Vol. XI, No. 9.

VISWANATHAN, P. (1946)—Beach minerals of Travancore *Sci. & Cult.,* Vol. XII, No. 1.

VISWANATHAN, P. (1946).—Thorium in Travancore, *Sci. & Cult.,* Vol. XII, No. 2.

VISWANATHAN, P. (1949).—Titanium in Travancore. *Sci. & Cult.,* Vol. XIV, No. 11.

VISWANATHAN, P. (1950).—Zircon and sillimanite in Travancore. *Sci. & Cult.,* Vol. 15, No. 11.

VISWANATHAN, P. (1953).—Thorianite in Travancore. *Min. Mag.,* Vol. 88, No. 5.

VISWANATHAN. P. AND SIRCAR. J. (1952).—Black sand of Puri sea beach. *Sci. & Cult.,* Vol. 18, No. 6.

OCCURRENCE OF SILICA SAND NEAR CHIRALA, GUNTUR DISTRICT.*

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DISTRIBUTION

A fairly good deposit of white sands containing a high percentage of quartz, occurs in a stretch of the country near Chirala (15° 54 :80° 12′). Owing to the high water table existing at the time of my visit, it was not possible to undertake satisfactory pitting operations. In a few trial pits dug water was encountered, in some cases, even before reaching the upper layers of the purer sand. It was therefore considered expedient to postpone the detailed investigation which involves a careful examination of a stretch of the country nearly 20 miles in length extending from Bapatla (15° 54′:80° 28′) to Kadavakuduru (15° 43′ 30″: 80° 15′ 15″) and 1 to 2 miles in width roughly between the Ramperu river and the Konduru "drain", or even some distance east of the "drain". Even while approaching the Ramperu river from the east, the soil becomes gradually clayey and finally gives place to the typical black soil of the region. West of the Konduru "drain" the mixed coastal sand rapidly replaces the white quartz sand.

The present reconnaissance has revealed that, in general, the western limit of the deposit does not extend beyond two furlongs west of the Madras-Bezwada railway line near Chirala and nearly ¾ mile from Kadavakuduru in the southern extremity. It may be mentioned that the best quality of quartz sand occurs between Bonnerupalem (15° 51′ 45″:80° 23′ 45″) about 3 miles north-east of Chirala and Pandillapalle (15° 45′ 30″:80° 17′ 30″), 6 miles south-west of Chirala. Fairly good quartz sand could be collected from this area, particularly west of the railway line near Chirala, at Jandrapeta (15° 48′ 15″:80° 20′) and Ipurupalem (15° 51′:80° 23′ 30″) and also from the areas between the rail and the road, the latter running more or less parallel to the line a furlong eastwards.

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* Based on report submitted in 1945 and published by the *Government of Madras, Development Department*, as G. O. No. 3065, dated the 9th August, 1946.

Some samples were collected for preliminary tests and analyses; the various localities with the overburden of impure sands at each place, are indicated in Table I. It was not always possible to determine the actual thickness of the layer of good sands for reasons already mentioned above. But in Table I, I have indicated the probable thickness of the white sands at each locality sometimes based on information gathered locally.

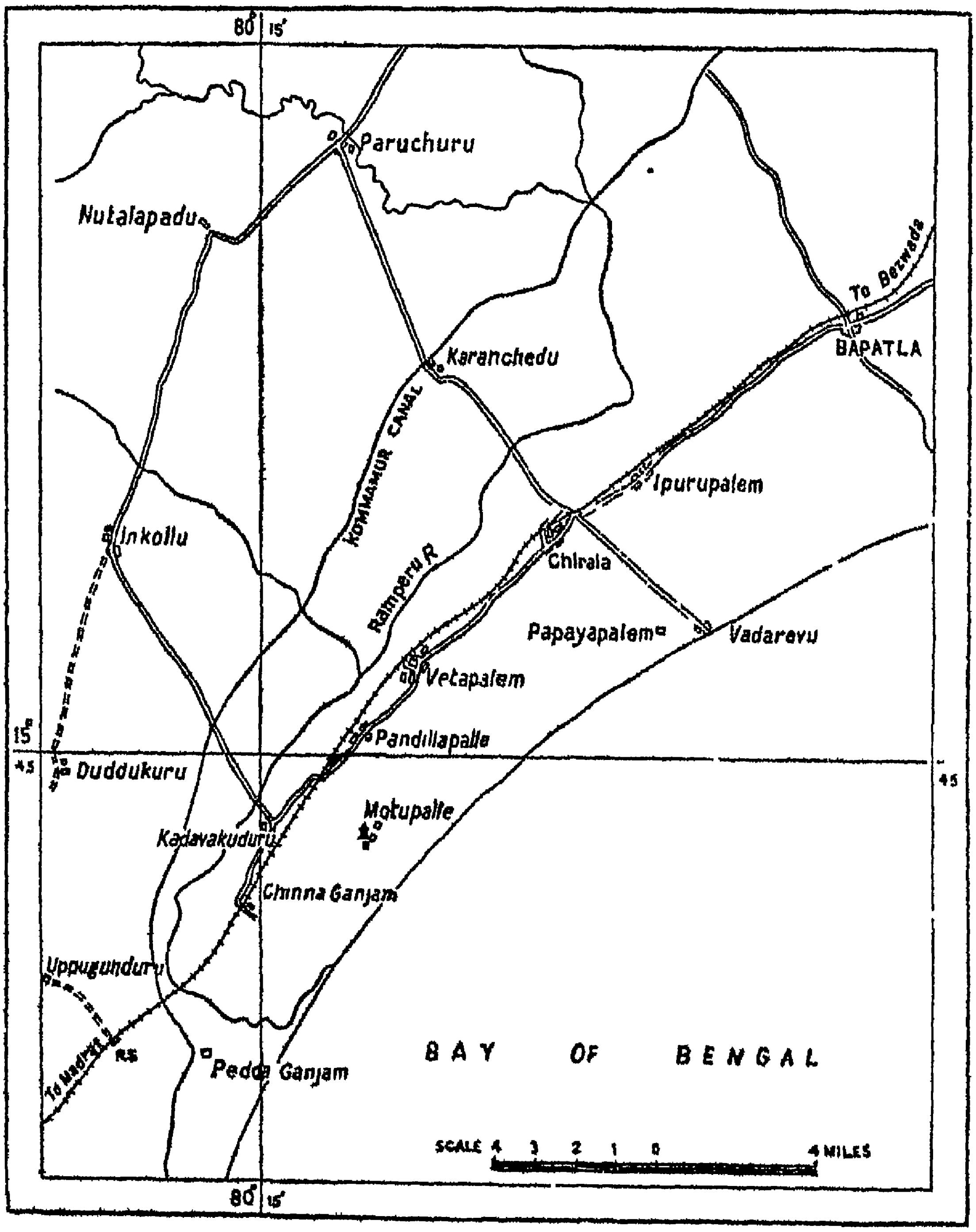

TABLE I.

Serial number.	Specimen number.	Locality.	Approximate distance from Chirala railway station.	Co-ordinates.	Approximate thickness of overburden.	Thickness of white sands.**
1	21	Just south of track to Swarna and west of railway line.	6 furlongs south-west.	15° 49′ 22″ : 80° 20′ 45″ ..	2—3 ft. ..	10 ft.
2	22	1 furlong north-west of Pata Chirala, 6 furlongs west of railway line.	2¼ miles south-west.	15° 48′ 45″ : 80° 19′ 52″ ..	4—6 ft. ..	6—8 ft.
3	23	Opposite to Kadavakuduru railway station. close to station, east of railway line.	9½ miles south-west.	15° 43′ 22″ : 80° 15′ 47″ ..	2—3 ft. ..	6 ft.
4	24	1½ furlongs west of Chirala railway station, west of railway line, from pit in field.	1½ furlongs west .	15° 48′ 52″ : 80° 21′ 15″ ..	3—4 ft. ..	6—9 ft.
5	25	About 5 furlongs west-south-west of Chirala railway station and 1 furlong north of track to Swarna, west of railway line.	5 furlongs west-south-west.	15° 49′ 30″ : 80° 20′ 45″ ..	3—4 ft. ..	5 ft.
6	26	10 yards south of above locality, west of railway line.	5 furlongs west-south-west.	15° 49′ 30″ : 80° 20′ 45″ ..	6—8 ft. ..	5 ft.
7	27	1 furlong south of Chirala-Swarna cart track and about a mile south-west of Chirala railway station, west of railway line.	1 mile south-west	15° 49′ 22″ : 80° 20′ 45″ ..	7—8 ft. ..	9 ft.

**Owing to the high water table at the time of my visit to the area, the actual thickness of the layer or layers of good white sand could not be determined in every case.

The figures given in this column are in some cases from information gathered locally.

TABLE I—*contd.*

Serial number	Specimen number.	Locality.	Approximate distance from Chirala railway station.	Co-ordinates.	Approximate thickness of overburden.	Thickness of white sands.*
8	28	North 25° west of Pata Chirala and 2 furlongs from village, west of railway line.	2 miles south-west	15° 48′ 52″ : 80° 20′ 15″ ..	3—4 ft. ..	8—9 ft.
9	29	North 35° west of Pata Chirala and about 2 furlongs south-west of 28, west of railway line.	2½ miles south-west	15° 48′ 45″ : 80° 20′ 7″ ..	3 ft. ..	8 ft.
10	30	About 2 furlongs north-east of Jandrapeta, east of railway line.	2 miles south-west	15° 48′ 30″ : 80° 20′ 22″ ..	3 ft. ..	(?)
11	31	About 2 furlongs east of Pata Chirala, east of railway line.	2 miles south-west	15° 48′ 37″ : 80° 20′ 20″ ..	3 ft. ..	8—10 ft.
12	33	1 mile east-north-east of Chirala railway station, east of railway line.	1 mile east-north-east.	15° 50′ 30″ : 22′ 30″ ..	3—5 ft. ..	(?)
13	34	About 1 mile 1 furlong east-south-east of Chirala railway station, east of railway line.	1 mile and 1 furlong east.	15° 49′ 45″ : 80° 22′ 30″ ..	4—5 ft. ..	(?)
14	35	About 6 furlongs east-north-east of Chirala railway station, east of railway line.	6 furlongs east-north-east.	15° 50′ 30″ : 22′ 7″ ..	10—12 ft. ..	10 ft.
15	36	About 8 furlongs north-east of Chirala railway station, east of railway line.	8 furlongs east-north-east.	15° 50′ 30′ : 22′ 15″ ..	5—6 ft. ..	10—12 ft.
16	37	1 furlong north-west of Ipurupalem, west of railway line.	2 miles 6 furlongs north-east.	15° 51′ 15′ : 80° 23′ 22″ ..	3 ft. ..	8—10 ft.

17	38	1 furlong west of Ipurupalem, west of railway line.	2 miles and 4 furlongs north-east.	15° 51′ 7″ : 80° 23′ 15″	..	6 ft.	..	10—12 ft.
18	39	1½ furlongs north-west of Stuartpuram, west of railway line.	5 miles and 2 furlongs north-east.	15° 52′ 37″ : 80° 25′	..	6—8 ft.	..	(?)
19	40	2 furlongs east of Kadavakuduru, west of railway line.	9½ miles south-west	15° 43′ 37″ : 80° 15′ 37″	..	5—6 ft.	..	6—8 ft.
20	41	About 3½ furlongs east of Kadavakuduru, east of railway line.	9½ miles south-west	15° 43′ 37″ : 80° 15′ 45″	..	2—3 ft.	..	6—8 ft.
21	42	½ mile south-west of Vetapalem, east of railway line.	6 miles south-west	15° 46′ 15″ : 80° 18′ 7″	..	4—6 ft.	..	10—12 ft.
22	43	6 furlongs south-west of Vetapalem, east of railway line.	6 miles and 1 furlong south-west.	15° 46′ 7″ : 80° 18′	..	2—3 ft.	..	8—10 ft.
23	44	3 furlongs north of Desayapeta, east of railway line.	3½ miles south-west	15° 47′ 45″ : 80° 19′ 30″	..	6—8 ft.	..	10—12 ft.
24	45	About 1 mile north-east of Stuartpuram, east of railway line from bank of canal on sand heap.	6 miles and 2 furlongs north-east.	15° 53′ 7″ : 80° 25′ 52″	..	Surface	..	(?)
25	46	½ mile east of Pata Chirala, east of railway line.	1 mile and 6 furlongs south-west.	15° 48′ 45″ : 80° 20′ 37″	..	12 ft.	..	8—12 ft.
26	..	2 furlongs south of Vetapalem railway station, east of railway line.	5½ miles south-west	15° 46′ 45″ : 80° 12′	..	5—6 ft.	..	(?)

** Owing to the high water table at the time of my visit to the area, the actual thickness of the layer or layers of good white sands could not be determined in every case.

The figures given in this column are in some cases from information gathered locally.

TABLE I—*contd.*

Serial number.	Specimen number.	Locality.	Approximate distance from Chirala railway station.	Co-ordinates.	Approximate thickness of overburden.	Thickness of white sands.**
27	..	Baer Hospital compound close to mile 42, east of railway line.	Less than 2 miles	15° 48′ 52″ : 80° 20′ 37″ ..	5—6 ft. ..	10—12 ft.
28	..	6 furlongs north east of Stuartpuram railway station, east of railway line.	6 miles . .	15° 52′ 45″ : 80° 25′ 45″ ..	8—12 ft. ..	(?)
29	..	1 furlong south-west of Ipurupalem, east of railway line.	2 miles 4 furlongs	15° 51′ : 80° 23′ 15″ ..	6—8 ft. ..	8—10 ft.
30	..	About 1 mile 1 furlong east-south-east of Chirala railway station close to Vadarevu road, east of railway line.	1 mile 1 furlong .	15° 49′ 30″ : 80° 22′ 37″ ..	7—12 ft. ..	(?)

** Owing to the high water table at the time of my visit to the area, the actual thickness of the layer or layers of good white sand could not be determined in every case.

The figures given in this column are in some cases from information gathered locally.

The samples are representative only of that thickness of the layer of good white sands which it was convenient to reach. The samples were coned and quartered before collection. However, they give a fair idea of the nature of the sands and, for a preliminary investigation, may provide fairly satisfactory data. According to local information, in many places the thickness of the white sands exceeds 10 feet. At the time of my visit just after the north-east monsoon, it was not quite practicable either to verify this statement or to determine whether the deposits continue in depth without any intervening layers of impure sands or whether the sands improve in quality further below. A detailed investigation of the area should be carried out sometime after April and before October. Sufficient number of suitable samples should be collected at various depths along the whole stretch of the deposits for detailed physical and chemical tests, depending on the variability of the deposit.

The white sands are everywhere covered over by a layer of impure sand varying in thickness from place to place from 2 feet to anything up to 12 feet or more. In general it may be stated that the overburden becomes heavier as one proceeds towards the Konduru "drain" in the east on account of the large sand dunes on its either side. Further east of the drain the overburden is again lighter; but the sand appears to be of inferior grade, often largely mixed with heavy minerals. The better quality is apparently confined to the western half of the stretch.

ORIGIN

The deposit of white sands may be said to be "secondary" in the sense that they have been probably removed from the place of their original deposition and re-deposited. There is a preponderating percentage of quartz, while some felspar is present in the greater part of the area with very small percentage of ilmenite, magnetite, epidote, etc. It is likely that the sands were originally derived from the crystalline rocks probably from pegmatites. The nature of the underlying rocks near Chirala is not known. According to local information even the deepest wells in Chirala tap water from the underlying sands. The present deposits lie nearly sixteen miles from the gneissic boundary. The Gondwanas composed of shales and ferruginous sandstones are the nearest to the deposits of sands; but it is unlikely that the sands were derived from this formation. Their possible origin from the Cuddapah quartzites is worth consideration.

It is possible in my opinion that the originally mixed sands were thrown up by the sea and later concentrated by the continuous action of the slow moving waters of the Ramperu river and the Konduru "drain" which, unlike the other streams of the area, run almost parallel to the coast. The grains of sand are angular to sub-angular and usually form an irregular mixture of different sizes except in the case of two or three samples. Comminuted shells are rarely present. The texture and shape of grains and the composition of the sand seem to indicate that the white quartz sands were most probably re-deposited as fluviatile or partly lacustrine sediments. The percentage of felspar present also seems to indicate that the sands have undergone little transportation by rivers and have been subjected to comparatively slight action by water.

PROPERTIES OF THE SAND

In testing sands for any purpose it is of course essential that the samples should be representative, but as already pointed out above it was not always practicable to collect samples representative of the whole thickness of the deposit. It is hoped, however, that the samples obtained during this preliminary reconnaissance would give satisfactory results which may prove helpful in any future detailed investigation. While collecting samples the surface layer of impure sands was scrupulously avoided.

(i) *Chemical composition.*—Analysis of seven selected samples of the sand gave results shown in Table II.

(ii) *Mineral composition.*—The proportion of mineral impurities in sands varies according to their mode of origin. The minerals which I have been able to identify besides quartz, are felspar in some proportion, and very small percentages of ilmenite, magnetite, epidote, monazite and garnet and traces of muscovite and biotite. Organic matter and comminuted shells are rarely present. A cursory examination reveals that monazite, garnet, muscovite and biotite, whenever present, are found only in slight traces in some of the samples. Table III gives the impurities present and the approximate size of grains of some of the minerals.

The quartz grains which are usually of the largest size are generally clear, transparent and angular with very few that are rounded. In some samples there is a covering of "dust" particles on the quartz and felspar grains. Except for three or four samples collected near Chirala the grains of quartz are found in various sizes. They are coarsest towards the southern extremity around Kadavakuduru where the percentage of felspar also increases considerably. But even here layers of

TABLE II.

Serial number.	Specimen number.	Percentage.							
		Silica.	Alumina.	Iron Oxide.	Lime.	Magnesia.	Alkalies.		Loss on ignition.
							Na_2O	K_2O	
1	24	91.33	5·02	0·48	0·22	0·41	0·97	1·51	0·24
2	25	92·01	4·55	0·47	0·11	0·70	0·75	1·46	0·22
3	31	91·15	5·12	0·32	0·16	0·42	1·16	1·42	0·32
4	36	90·92	4·52	0·33	0·15	0·72	1·16	1·82	0·48
5	37	91·01	5·02	0·48	0·18	0·61	1·22	1·41	0·22
6	40	91.30	4·88	0·32	0·11	0·29	1·61	1·63	0·20
7	42	86·52	7·43	0·49	0·31	0·91	1·49	2·56	0·30

TABLE III.

Serial number.	Specimen number.	*Quartz.* Average grain size in mm.	*Iron stained quartz.* Comparative occurrence.	*Quartz with adherent black mineral.* Comparative occurrence.	*Felspar.* Average grain size in mm.	*Felspar.* Comparative occurrence.	*Heavy minerals.* Average grain size in mm.	*Heavy minerals.* Comparative occurrence.	*Organic matter.* Comparative o currence
1	24	0·12—0·5 (0·2)	×	..	0·27—06	×	0·14	××	..
2	25	0·1—0·65 (0·18)	×	..	0·225	×	0·15	××	Traces.
3	27	0·18—2·0 (0·6)	××	..	0·75	××	0·18	××	..
4	28	0·09—0·525 (0·16)	Traces.	..	0·225	×	0·09	××	Traces.
5	31	0·15—2·5 (0·75)	×	..	0·95	××	0·15	Traces.	Traces.
6	36	0·225—1·4 (0·525)	×	×	0·33—1·825 (0·4)	××	0 18	×	..
7	37	0·15—0·75 (0·375)	×	..	0·45	××	0·15	××	Traces.
8	38	0·06—1·75 (0·75)	×	×	0·3—1·0 (0·525)	××	0·18	××	..
9	40	0·375—4·0 (1·25)	×	×	0·6—2·0 (0·9)	××	0·18	Traces.	Traces.
10	42	0·18—2·75 (0·875)	×	×	0·225—1·25 (0·525)	××	0·18	×	..
11	44	0·15—2·0 (0·75)	×	×	0·225—1·25 (0·6)	××	0·225	×	Traces.
12	46	0·15—1·25 (0·45)	×	×	0·225—1·0 (0·4)	××	0·225	×	..

different texture may occur at different depths. This has to be tested; but as yet we know little of the deposits of sand occurring deeper down.

Some of the coarser samples show a few grains of quartz with enclosed particles of heavy minerals. A thin film of red ferruginous matter is seen coating a few grains of quartz in some of the samples.

The coarser samples particularly near Kadavakuduru in the southern parts of the deposit contain a larger proportion of felspar than the finer sands collected near Chirala. The felspars occurring in the samples are very much clouded and corroded and generally show a glazed appearance with their angularities unlike the quartz grains, considerably smoothened out. The grain size although on the whole is not very different from that of quartz the average in any sample is usually smaller.

The heavy minerals are found only in low percentage and in some samples only in traces. The grains are less angular and their size is considerably smaller than those of quartz and felspar. Their comparative occurrence in the various samples are roughly indicated by cross-marks in Table III. The coarser samples contain a lower percentage of the heavy minerals than the finer grained. Some of the black minerals are seen as inclusions in the larger quartz grains. Limonite is rarely present. Ilmenite and epidote are present in low percentages. Monazite and garnet are very rare. Biotite and muscovite are found in traces in one or two samples, but the grains are usually larger than the average heavy mineral grains on account of their flaky nature. Organic matter and comminuted shells are rarely observed.

(iii) *Physical properties.*--The sands are generally *clean* with very little colloid matter or "dirt". Some of the grains of quartz and felspar are found to be slightly coated with minute particles making the quartz grains somewhat opaque. Such samples, when washed, yield this "dirt", chiefly in suspension.

The transparency of sands (*see* Table IV) depends on the nature of the minerals and the impurities present. The quartz grains which preponderate make the sands almost transparent. The partially decomposed felspars are clouded, white and opaque. The heavy minerals are dark and opaque. In general, the samples of sands are transparent to translucent and even partly opaque.

The *colour* of the sands (*see* Table IV) is almost white with a slight tinge of grey or buff. The clouded white grains of felspar are shown up among the transparent quartz. The colour of the sand improves on washing.

The *shape* of the quartz grains is angular to sub-angular (*see* Table IV). But rounded grains are also found. While the felspar is less angular than quartz, the heavy mineral grains are usually well rounded.

The texture of grain size of sand is an important property on which its value depends to some extent. The samples collected show different textures (*see* Table IV). Some are uniformly fine-grained, while others are mixed and predominantly coarse-grained with a good percentage of grains of smaller size. Results of sieve tests are shown on Table V. The percentages of the different graded size present in the twelve selected samples are shown therein. While the samples collected near Chirala are fine-grained, the sands are very coarse, particularly near Kadavakuduru towards the southern limits of the deposit. Medium and moderately coarse sands are also present in other localities.

The shape and size of the quartz grains are important. While grains of certain size may be desirable in some industries, they may be unsuitable in others. Thus for glass making a uniform round grained sand is most valuable. The proportion of grains of various sizes present in a sand is also of some importance in glass making, foundry practice, etc. By using sieves of suitable mesh size the desirable texture needed for the particular industry can be obtained, provided the sand is otherwise suitable.

The *specific gravity* of the several samples of sand is given on Table VI. The specific gravity of pure quartz is 2·65. The variation shown by the different samples gives an indication of the impurities present.

Seger cone tests of the *refractoriness* of the samples of sand could not be carried out. It may, however, be mentioned that the presence of impurities hastens the melting of sands when heated. Conversion is rapid in the presence of fluxes than in a pure quartzose sand. The occurrence of more than one oxide renders the quartz sand more fusible than if only one is present. Felspar shows signs of fusion at about 1190° C. and fuses completely at about 1300° C. All the other minerals recognized in the various samples also possess lower melting points than a pure quartz sand, thus lowering the refractoriness of the sand to some extent.

The size of grains also effects the fusibility of the sands. The coarser grains are more refractory than the finer and depending

TABLE IV.

Serial number.	Specimen number.	Colour of sand (unwashed).	Shape of quartz grains.	General texture of sand.	"Cleanness."	Transparency.
1	24	Very light grey, almost white.	Angular to sub-angular	Fairly uniform, fine to very fine sand.	Slight dirt	Nearly transparent.
2	25	Do.	Do.	Fairly uniform, fine sand.	Do.	Do.
3	27	Very light grey, buff	Do.	Somewhat mixed, medium sand.	Do.	Translucent.
4	28	Very light grey, almost white.	Do.	Uniform, fine to very fine grained sand.	Very slight dirt	Do
5	31	Very light buff	Sub-angular	Mixed, coarse to medium sand.	Slight dirt	Do.
6	36	Do.	Do.	Somewhat mixed, coarse sand.	Do.	Do.
7	37	Do.	Do.	Fairly uniform, medium sand.	Very slight dirt	Do.
8	38	Very light greyish buff	Angular to sub-angular	Somewhat mixed, coarse to medium sand.	Slight dirt	Do.
9	40	Very light grey	Sub-angular	Mixed, very coarse sand	Dirt present	Translucent to opaque.
10	42	Very light greyishbuff	Angular to sub-angular	Mixed, coarse to medium sand.	Do.	Do.
11	44	Very light buff	Do.	Do.	Slight dirt	Do.
12	46	Do.	Sub-angular	Fairly uniform, medium sand.	Do.	Do.

TABLE V.

Serial number.	Specimen number.	Sieve mesh.					
		30 mesh percentage weight.	60 mesh percentage weight.	90 mesh percentage weight.	120 mesh percentage weight.	Finer sand percentage weight.	Loss on sieving.
1	24	0·88	6·52	49·09	25·58	7·36	0·57
2	25	3·45	22·375	55·405	12·035	6·555	0·18
3	27	17·27	76·54	5·38	0·37	0·28	0·16
4	28	0·14	5·52	58·38	26·56	9·02	0·38
5	31	41·94	55·35	2·28	0·28		0·15
6	36	24·52	60·10	13·68	0·76	0·78	0·16
7	37	2·63	64·06	30·82	1·39	0·85	0·25
8	38	30·48	54·37	13·08	0·82	0·83	0·42
9	40	80·30	17·45	1·765	0·058		0·427
10	42	46·02	30·52	12·23	1·50	0·61	0·12
11	44	23·12	69·66	6·44	0·58		0·2
12	46	11·96	70·90	16·40	0·44	0·13	0·17

TABLE VI.

Serial number.	Specimen number.	Specific gravity.	Serial number.	Specimen number.	Specific gravity.
1	24	2·528	7	37	2·561
2	25	2·554	8	38	2·600
3	27	2·559	9	30	2·549
4	28	2·549	10	42	2·556
5	31	2·536	11	44	2·597
6	36	2·573	12	46	2·589
				Average .	2·557

on the use to which a sand is put, separation of the coarse and finer particles will be useful. For use as moulding sands separation of the more refractory constituents is of value, as it is not generally the refractoriness of the sand as a whole that is of importance, but its tendency to fuse in isolated patches.

According to some authorities the proportion of various fluxes which effect an equal reduction of the refractoriness are magnesia 20, lime 28, potash 47, soda 31 and red iron oxide 40.

The *permeability* of sands to liquids and gases is an important property especially where the sands are used for moulding and filters. This property depends chiefly on the shape, size and texture of the sand and the amount of clayey matter present. No elaborate tests were carried out on these sands. But it may be stated that the most permeable sands are those composed of moderately large size, uniform sub-angular grains, while the fine sands with angular grains and traces of clayey matter are usually less permeable. Clay matter, if at all present in the samples collected, is found only in small traces. The grains are angular to sub-angular. While some samples are uniformly fine grained, others are coarse mixtures. The latter are generally less permeable as the finer grains fit into the spaces between the larger, angular grains.

POSSIBLE USES OF CHIRALA SANDS

(i) *For the manufacture of glassware*—(*a*) *General*.—The purity of the sand used for the manufacture of glassware varies according to the type of glass to be made. The purest sands, preferably containing 99·5 per cent. to 99·8 per cent. of silica, are used for the manufacture of high grade colourless ware. For inferior types, a lower percentage would suffice. Organic matter, alumina, iron compounds and, to a smaller extent, lime and other bases are injurious. It has been estimated that the sands used for the manufacture of high grade silicaware should not contain more than 1 per cent. of all these impurities. Alumina should not exceed 0·05 per cent. Iron oxide is harmful beyond 0·02 per cent. All the other oxides should preferably remain below 0·5 per cent.

The shape of the grains is not important; but the size should be as uniform as possible, as a sand consisting of uniform grains will melt more quickly and produce a homogenous glass. When the sand is not properly graded the finished product will show unmelted particles. A grain size between ·005 inch and ·012 inch would be best. A sand that is between 30 mesh and 120 mesh size is quite suitable.

(*b*) *Some impurities in the Chirala sands and methods to remove them.*—The organic matter present in some of the samples should be removed as it will give rise to black spots which are rarely burnt out when heated. Organic matter can be removed by washing when most of the impurities like fragments of dried leaves and rootlets will float. For special glasses addition of nitre to the batch is sometimes resorted to, to help the oxidation of organic matter.

"Dirt" and colloidal matter present in traces can be removed by washing and sieving. In the manufacture of glassware where a loose and incoherent sand is required, the presence of clay is deleterious. It also tends to introduce such impurities as alkalies, iron compounds, etc., which are undesirable in glass sands.

The heavy minerals present in varying proportions in the different samples introduce iron compounds which impair the colour of the glass. The iron compounds contained in epidote, garnet and in mica, particularly biotite, are harmful in glass sands. The presence of iron oxide gives a greenish tint to the finished product depending to a great extent on the proportion of iron present.

The accompanying table (Table VII) indicates the approximate percentage of iron oxide present in a sand and the colour of the resultant glass.

Table VIII gives an indication of the amount of iron present in some of the types of glasses manufactured. The use of decolourizers like nickel oxide, manganese dioxide or selenium permits a higher percentage of iron content except in the case of the best glasses.

Most of the heavy minerals are confined to the finest grains whose removal considerably improves the purity of the sands. Thus screening and washing which are most helpful, removes not only the iron compounds but also the dirt and organic matter present in the sands. The coarser samples occurring near Kadavakuduru and other localities contain very small percentages of heavy minerals. Generally screening is found to improve the colour of the sands. The sieved product containing the finest grains is much darker in tint owing to the accumulation of the heavier minerals. Magnetic separation may also be found helpful in removing the magnetically susceptible heavy minerals left behind even after washing and sieving.

Iron present in some of the samples as limonite, iron stained quartz and also as inclusions in quartz grains, is not easily eliminated by mechancial means. Limonite may be removed to some

TABLE VII.

(After Searle.)*

Percentage of iron oxide.	Colour of glass.	Percentage of iron oxide.	Colour of glass.
Less than 0·02	Colourless.	0·1—0·3	Yellowish green.
0·02—0·05	Almost colourless.	0·3—1·0	Green.
0·05—0·1	Faintly green.	1·0—2·0	Dark green.

TABLE VIII.

(Based on data after Searle.)*

Percentage of iron oxide in sand.	Manufactured product.	Percentage of iron oxide in sand.	Manufactured product.
Not more than 0·02	Optical glass with zinc and barium compounds.	Not more than 0·05	Plate glass.
		Not more than 0·1	Mirror glass.
Not more than 0·03	Optical glass.	Up to 0·2	Poorer quality of plate.
Less than 0·04	Crystal glass for cut glass work.	0·5—7·0 (1·5 average)	Bottle glass.

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* Searle, A B, Sands and Crushed rocks, Vols. I, II, London.

extent by tabling or some form of gravity separation as it has a higher specific gravity than quartz and felspar. Washing often helps to clean the quartz grains of their coating of iron oxide to a great extent. Heavy minerals adherent to quartz are generally difficult of removal.

Chemical purification of sands is very expensive and is used in special cases, particularly in the removal of iron compounds from sands used for making optical glassware. Some of the methods are mentioned on a later page.

Alumina is another impurity occurring in the Chirala sands particularly in the form of felspar, as traces of muscovite in one or two samples and possibly in the small percentages of colloidal matter present. Of these feldspar is the most serious impurity difficult of complete elimination. Clay or "dirt" and mica may be removed by washing and screening.

A high percentage of felspar will make the resulting glass turbid if the manufacture of crystal clear glass is the objective. For opaque glassware, however, a small percentage of felspar is helpful.

In small proportions alumina is a useful ingredient in the manufacture of glasses which have to be subjected to pressure or heat such as thermometers, combustion tubes, etc. The presence of the oxide brings about a reduction of the co-efficient of expansion and increases the hardness and strength of the glassware. On the other hand, alumina, especially in excess of 3 per cent., decreases the fusibility and increases the viscosity of glass.

It is difficult to separate felspars from quartz by mechanical means as the specific gravity of the two is not very different from each other. Perhaps flotation processes may prove helpful if they can be done cheaply.

For optical glassware the presence of alumina is best restricted to less than 0·5 per cent. Up to 3 to 6 per cent. of alumina may be allowed in green bottle glass. It is doubtful if any of our samples can be brought to a high degree of purity by ordinary methods.

The presence of *magnesia*, beyond very small quantities, is very undesirable as it makes the glass "stringy" and creates a tendency to form "stones". It is expected that the percentage of magnesia is fairly low in our samples.

The grain *size* of Chirala sands varies from place to place; it is preferable to use a fairly uniform sand to facilitate smooth chemical reaction. The finer particles which pass through a 120 mesh sieve may be discarded as the impurities, chiefly heavy minerals, are present as fine grains. Besides, very fine sand often remains in suspension and produces turbidity instead of settling during the process of " fining ".

Some of the samples collected are very coarse-grained. They may be crushed to some extent after mechanical purification. Further sieving will separate the sands into grades. Grinding, however, increases the cost of production, and for the manufacture of ordinary glassware grinding may not be profitable when natural fine grained sands are available near at hand.

(ii) *As refractory material.*—The properties required in sands used for *hearths and linings* are mainly refractoriness and inertness to the metals and slags with which they come in contact. The fusibility of our samples has not been tested for want of proper facilities. In general, linings of metallurgical furnaces should preferably contain 95 to 99 per cent. of silica. In the smelting of copper and some of the other metals a lower percentage of silica may be used because of the lower temperatures at which these furnaces are used. In small proportions clay is not harmful. In fact a certain proportion of clay is beneficial in many cases.

Although less than 1 per cent. of organic matter may not be harmful, it is generally undesirable in sands used for furnace hearths. Only traces of organic matter are present in our samples which can be easily removed by washing.

Iron compounds over 1 per cent. are not advisable: but their proportion can be brought down considerably as already mentioned elsewhere.

Fluxes introduced into the sand chiefly by felspar are deleterious as they decrease the refractoriness of the material. More than 2 per cent. of lime, magnesia and alkalies will be harmful. It is therefore doubtful if the Chirala sands can be successfully used as refractory material in open hearth furnaces. The somewhat high percentage of felspar present in the majority of the samples collected would make the sand fusible, unless some suitable methods could be devised to remove a good part of the mineral.

Refractory silica bricks used in furnaces where strength is required at high temperatures, demand high silica (96 per cent. to 98 per cent.) with only 2 to 4 per cent. of other oxides as impurities. Sands containing lower percentages of silica may also form excellent refractories provided the fluxes present are low.

(iii) *As moulding sand.*—In casting metals and alloys different kinds of sands are used in various ways. Siliceous sands varying from almost pure silica to mixtures containing a good percentage of clay are used. The high silica sands usually require an artificial bond to give them the necessary cohesion and plasticity.

The refractoriness of a moulding sand is of utmost importance as it will have to withstand the high temperatures of molten metal with which it comes in contact. While the sands should be highly refractory for casting steel and high temperature alloys, less refractory sand would suffice for brass and other non-ferrous alloys.

A pure quartz sand does not fuse below a temperature of 1700° C. The following figures of casting temperatures of steel, iron and brass would help to indicate to some extent the demand for varying grades of sands:--

	Maximum temperature attained.
Steel	1580 C. to 1650 C.
Iron	1510° C.
Brass	1350° C.

Organic matter is found only in traces which as already mentioned, can be easily removed. To increase the permeability of the sands in order to enable the escape of gases in mould, carbonaceous matter is sometimes added.

The amount of *clay* present in the samples is almost insignificant. A percentage of suitable clay with good bonding power will have to be added to the more suitable sands to make them sufficiently strong to form moulds. To avoid shrinkage and decrease in permeability the clay added should be just sufficient to impart the necessary cohesion to the mould.

The percentage of *silica* generally required in moulding sands for casting some of the metals and alloys may be found instructive.

Light brass . . .	78 to 80 per cent.
Light cast iron and heavy brass	80 to 82 ,,
Medium cast iron .	82 to 84 ,,
Heavy cast iron .	84 to 88 ,,
Steel	90 to 99 ,,

Alumina in excess of 13 per cent. would make the sand not quite useful for moulding. Felspar which is present in some proportion in the majority of our samples would be objectionable where a highly refractory material is required. But in the case of non-ferrous metals and alloys a high percentage is generally admissible as the felspar melts at a higher temperature than the metals and alloys cast. The presence of small quantities of felspar is however advantageous as the mineral on melting forms a good bond giving strength to the mould; but this should not take place at the expense of permeability.

Iron compounds in suitable state of combination are advantageous in moulding sands, particularly in the form of limonite and similar ferric compounds. They give a better finish to the mould than clay and enable the metal to be separated more easily from the mould. Even 2 to 3 per cent of iron oxide is not harmful in refractory moulding sands, and much higher proportionate even 11 to 12 per cent., are permissible for certain metal castings.

Lime may be present in small proportions in the samples. For steel casting, sand with less than 0·1 per cent. lime is preferable while 1·5 per cent. is permissible in the case of iron and 2·5 per cent. for brass. For other metals with lower melting points about 4 to 6 per cent. may be allowable.

Magnesia should be absent as far as possible and preferably the total quantity should not exceed 0·5 per cent. and *alkalies* not more than 1 per cent.

The percentage of *soluble salts* is not known; but if they are present, the refractories and permeability of the sands may be reduced.

Some of the *physical properties* of a moulding sand, such as permeability and binding power, depend on the shape, size and texture of sands. The Chirala sands are fine grained to coarse grained and the samples are fairly permeable. The type of sand suitable for floor, facing and core will be different. It would appear that the sands may be suitably prepared for general moulding work. Detailed tests will have to be performed to indicate their specific uses in foundries.

(iv) *For enamelling metals.*—A sand possessing almost the same properties as a glass-sand is required for enamelling metals. Silica in enamels gives it hardness and power to resist corrosion Usually 97 to 99 per cent. of silica with not more than 0·33 per cent. of iron oxide is required. A low percentage of alumina in the form of felspar is useful as it adds brilliance and increases the hardness and refractoriness of the enamel and also facilitates its adherence to the metal more firmly but excess of felspar would increase the viscosity of enamel. Small proportions of lime, potash and soda are permissible, but magnesia must be very low as it makes the enamel viscous.

The Chirala sands are not sufficiently pure to be used in adding silica to metals or for smelting ores; nor can they be used in the chemical industry without purification.

SOME METHODS TO IMPROVE THE QUALITY OF CHIRALA SANDS

(i) *Screening* is very desirable to isolate the heavy minerals which are usually confined to the finer particles. This process improves the colour of the sand appreciably. By employing suitable screens uniformity in grains, where it is demanded, can be obtained. A mixed sand would also be required for certain purposes. Some factories in India use 30 mesh and 120 mesh sieves. The fines are kept for sand blasting while those collected or the 30 mesh sieve are discarded.

(ii) *Washing* is very effective in removing clay, organic matter and also a major part of the heavy minerals. The sand can also be freed from any soluble salts that may be present. Adhering films of ferruginous material on quartz grains can also be removed to some extent. If washing fails to remove this impurity chemical methods may prove successful.

Large tank washers can be constructed locally. It has been suggested that Freygang separators installed at low cost are very useful giving satisfactory separation and fairly good range in grading. In India very few glass works use washed sands as washing is considered to be a costly item. The process undoubtedly improves the final product.

Nadel and Saxena designed a commercial washing plant consisting of three cement tanks at different levels and capable of washing about 5 tons of sand per day. The sand is screened through a 100 mesh sieve before washing, discarding the material passing through. According to them the cost of the installation for washing is estimated to come to about Rs. 500 while the sieving arrangement will cost about Rs. 200. The cost of purification of sand, it is reported, will not exceed Re. 1 per ton.

(iii) *Magnetic separation.*—The magnetically susceptible impurities, if found to persist even after screening and washing, may be removed by powerful electro-magnets. Some quartz grains with enclosed grains of heavy minerals found in small percentages in some samples, can also be removed to some extent. If electro-magnetic method does not succeed, these inclusions of heavy minerals will form a serious impurity difficult of complete elimination.

Lift, retaining or deflecting types of separators, which can be installed at low cost, may be used. Magnetic separators will be necessary only in the case of manufacture of higher grades of glassware.

(iv) *Chemical purification.*—Methods of chemical purification are very costly and are only used in the preparation of very high grade wares. For ordinary glass this mode of purification would be uneconomical as it would considerably raise the cost.

If any iron oxide remains behind the washed, screened and magnetically separated grains, addition of nitre cake would be of advantage. The percentage of iron oxide, it is said, may be reduced to even 0·03 per cent. in a sand containing 0·2 per cent. of this impurity. Sodium hydrosulphide serves the same purpose at a lower temperature. Treatment with hydrochloric acid is of value when the iron forms a thin coating on quartz grains. Common salt is cheaper than hydrochloric acid and sands mixed with salt and heated to redness would remove a good part of the iron impurity almost as effectively as hydrochloric acid. The ferric chloride formed volatilises.

PROBABLE RESERVES

For reasons already given at the outset, it was not possible to determine at the time of my visit, the total depth of the silica sands at the various localities. Nor was it possible to determine whether the sands occur in one continuous layer or in several layers interspersed with impure bands. In some places it was found that the sands continue in depth for more than 8 feet. According to local information white sands are met with even beyond 12 feet depth in many places. To determine the total reserves pits will have to be put down in the area between Bapatla and Kadavakuduru during the dry season when operations may not be interfered with by a high water table.

It may, however, be taken that the width of the deposits is over 2 furlongs, average thickness probably not less than 4 feet and length over 5 miles. But they will have to be prospected in detail.

QUARRYING OF SANDS NEAR CHIRALA

The overburden of impure sands varies from place to place but nowhere, as far as I have been able to examine, is it very thick. Fairly good sands can be worked close to the surface, west of the railway line, west-south-west and south-south-west of the station. Initial exploitation in this area holds out good promise.

Manual labour which is cheap in the Chirala area may be depended on for winning the sands at reasonable cost.

Drainage is likely to be a serious problem. Even in January, in many places water was encountered at a depth of 3 to 6 feet from the surface. Unless adequate arrangements are made to drain off the accumulated water by pumping, quarrying is likely to be held up for considerable periods of the year.

Care should also be taken that during the rainy season water does not flow into the working pits from the surface, bringing with it the impure sands.

The overburden should not be dumped in the area likely to contain good sands underneath. It is suggested that the impure sands may be safely removed to the margin of the black cotton soil area which lies less than 2 to 3 furlongs west of the railway line. The sands thus added to the heavy black cotton soil would also help to "lighten" it.

There are excellent transport facilities in the area. The Madras-Bezwada railway line runs more or less parallel to the coast from Bapatla up to Kadavakuduru and beyond, so that any place where the sands may be worked will be within easy access of the rail. There is also a good metalled road running more or less parallel to the railway line from Bapatla to Kadavakuduru. The Kommamur (Buckingham) canal which affords ample facilities for boat traffic during the major part of the year, can be reached by good metalled roads from Chirala (5½ miles), Vetapalem (3½ miles) or Kadavakuduru (3 miles).

Labour is cheap and plentiful in the whole area, particularly near Chirala. The cost of working the sands will therefore be low. In 1945 impure sands were sold in Chirala town at 8 annas per cart-load. The white sands were charged at the rate of Re. 1 to Rs. 1-8-0 per cart-load.

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SOME SELECTED REFERENCES.

ANON (1941).—The Indian glass industry. *Sci. & Clut.*, Vol. 6, No. 10.

ATMA RAM (1944).—The glass industry in India. *Journ., Sci. & Industr. Res.*, Vol. 3, No. 2.

KRISHNAN, M. S. (1952).—India's resources of glass making sands and ceramic clays. *Trans. Ind. Ceram. Soc.*, Vol. 11, No. 2.

MAJUMDER, S. C. AND SHARMA, K. D. (1954).—An investigation on some glass sands from South India. *Journ., Sci. & Industr. Res.*, Vol. 13A, No. 4.

MEHTA, D. R. S. (1951).—Report on glass making sands in parts of Vindhya Pradesh, Uttar Pradesh and Rajasthan. *Bull. Geol. Surv. India*, Ser. A, No. 3.

MISRA, R. C. AND SINGH, S. (1952).—A petrological study of some glass making sands of Allahabad and Banda districts, U.P. *Journ., Sci. & Industr. Res.*, Vol. 11B, No. 4.

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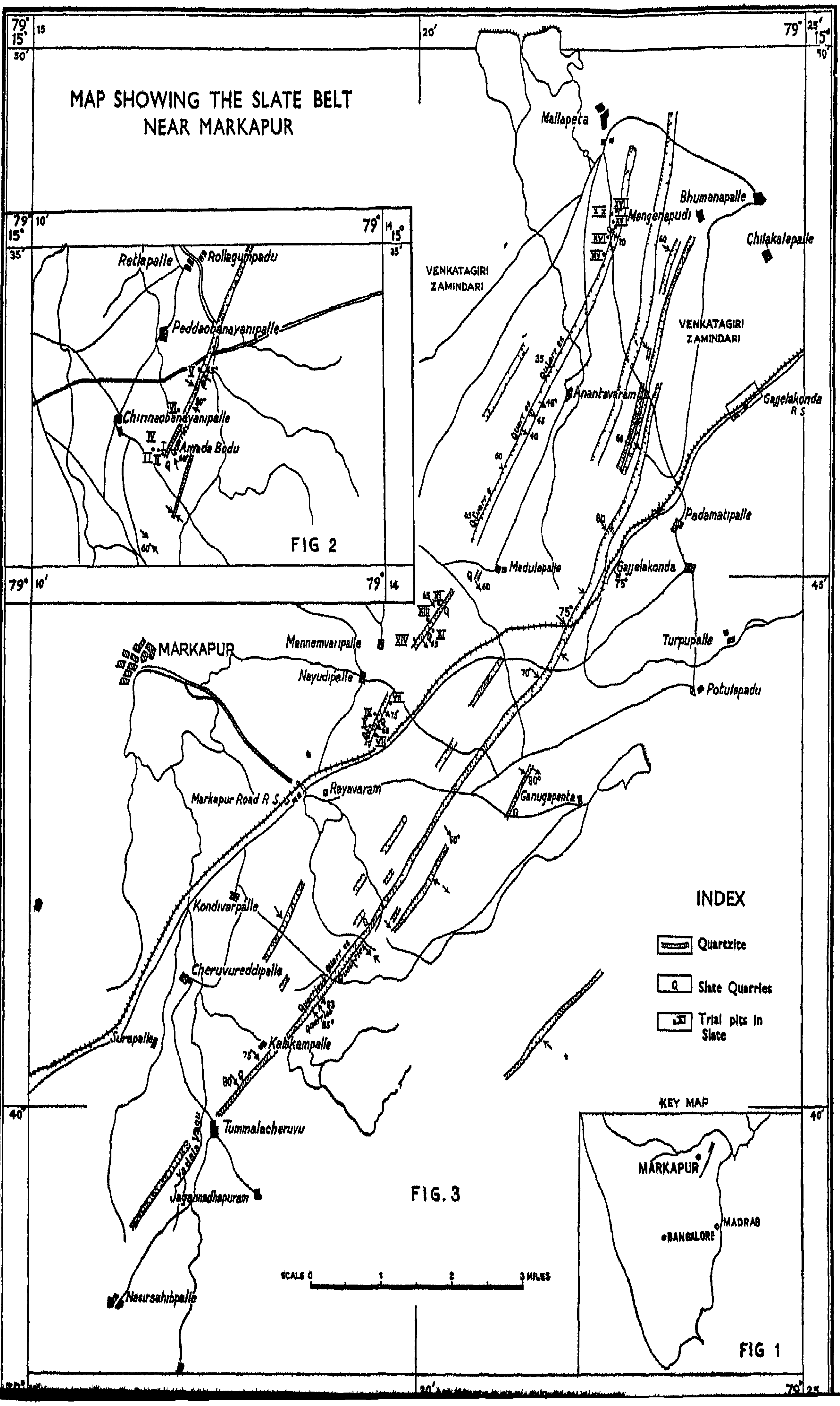

MAP SHOWING THE SLATE BELT NEAR MARKAPUR